PALÆONTOGRAPHICAL SOCIETY.

VOL. LVI.

CRETACEOUS LAMELLIBRANCHIA.

PART IV.

PAGES 145—196; PLATES XXVII—XXXVIII.

FOSSIL FISHES OF THE ENGLISH CHALK.

PART I.

PAGES 1—56; PLATES I—XIII.

BRITISH GRAPTOLITES.

PART I.

INTRODUCTION, PAGES i—xxviii.
PAGES 55—102; PLATES V—XIII.

BRITISH PLEISTOCENE MAMMALIA.

VOL. II, PART I.

PAGES 1—25; PLATES I—XIV.

ISSUED FOR 1902.

PALÆONTOGRAPHICAL SOCIETY.

VOLUME LVI.

CONTAINING

ISSUED FOR 1902.

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AGENTS FOR THE SOCIETY:
DULAU AND CO., 37, SOHO SQUARE, W.

DECEMBER, 1902.

THE PALÆONTOGRAPHICAL SOCIETY was established in the year 1847, for the purpose of figuring and describing British Fossils.

Each person subscribing One Guinea *is considered a Member of the Society, and is entitled to the Volume issued for the Year to which the Subscription relates.*

Subscriptions are considered to be due on the 1st of January in each year.

The Annual Volumes are now issued in *two forms of Binding:* 1st, with all the Monographs stitched together and enclosed in one cover; 2nd, with each of the Monographs in a paper cover, and the whole of the separate parts enclosed in an envelope. Members wishing to obtain the Volume arranged in the LATTER FORM are requested to communicate with the Secretary.

Most of the *back volumes* are in stock. Monographs or parts of Monographs already published can be obtained, apart from the annual volumes, from Messrs. Dulau and Co., 37, Soho Square, London, W., who will forward a complete price list on application.

Members desirous of forwarding the objects of the Society can be provided with plates and circulars for distribution on application to the Secretary, Dr. A. Smith Woodward, British Museum (Nat. Hist.), South Kensington, London, S.W.

The following Monographs are in course of publication:

- The Fossil Sponges, by Dr. G. J. Hinde.
- The Graptolites, by Prof. Lapworth, Miss Elles, and Miss Wood.
- The Cretaceous Lamellibranchia, by Mr. H. Woods.
- The Carboniferous Lamellibranchiata, by Dr. Wheelton Hind.
- The Inferior Oolite Ammonites, by Mr. S. S. Buckman.
- The Carboniferous Cephalopoda of Ireland, by Dr. A. H. Foord.
- The Sirenoid Ganoids, the Palæoniscid Fishes of the Carboniferous Formation, and the Fishes of the Old Red Sandstone, by Dr. R. H. Traquair.
- The Fishes of the English Chalk, by Dr. A. Smith Woodward.
- The Fauna of the Devonian Formation of the South of England, by the Rev. G. F. Whidborne.

The following Monographs are in course of preparation:

- The Carboniferous Lepidodendra, by Dr. D. H. Scott.
- The Fossil Cycadeæ, by Mr. A. C. Seward.
- The Reptilia of the Oxford Clay, by Dr. C. W. Andrews.
- The Cornbrash Fauna, by Prof. J. F. Blake.

ANNUAL REPORT

OF THE

PALÆONTOGRAPHICAL SOCIETY, 1902,

WITH A

LIST

OF

The Council, Secretaries, and Members

AND

A LIST OF THE CONTENTS OF THE VOLUMES ALREADY PUBLISHED.

Council and Officers elected June, 1902.*

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* Modified by resolution of Council on 21st November, 1902, when the vacancy in the list of Vice-Presidents, caused by the death of the Rev. Dr. Wiltshire on 27th October, was filled by the Rev. Canon Bonney.

ANNUAL REPORT OF THE COUNCIL

FOR THE YEAR ENDING 31ST MARCH, 1902.

READ AND ADOPTED AT THE

ANNUAL GENERAL MEETING,

HELD BY KIND PERMISSION OF THE GEOLOGICAL SOCIETY AT THEIR APARTMENTS IN BURLINGTON HOUSE, JUNE 20TH, 1902.

DR. HENRY WOODWARD, F.R.S., PRESIDENT,

IN THE CHAIR.

THE COUNCIL, in presenting their Fifty-fifth Annual Report, have much pleasure in recording the continued prosperity of the Society. The Treasurer's financial statement is eminently satisfactory, and the original Monographs offered to the Society for publication are as numerous and valuable as at any previous period in its history.

The income during the financial year amounted to £610 1*s.* 4*d.*, and the total expenditure was £488 19*s.* 1*d.*, leaving a balance of £121 2*s.* 3*d.* to be added to the balance of £1005 19*s.* 11*d.* already standing to the Society's credit. The surplus is due to the circumstance that the volume for the year was somewhat smaller than usual, and contained eight plates for which most of the charges had been paid many years before. A donation of £25 4*s.*, for which thanks are due to the Rev. G. F. Whidborne, Vice-President, was also a welcome addition to the funds.

The Council have the gratification to announce that His Majesty the King has graciously consented to continue the patronage which was accorded for so many

years by Her late Majesty Queen Victoria, in subscribing for the Society's annual volume.

A few additional members have also joined the Society, and fortunately repaired the losses sustained by death and resignation. The most serious loss during the year was caused by the lamented death of Mr. J. C. Mansel-Pleydell, who was one of the oldest and most active members, and served for some time on the Council. The resignation of several small libraries, after a brief period of subscription, is also regrettable, and serves to emphasise the importance of securing new personal subscribers who will take an active interest in the Society's work.

The volume for 1901 was issued at the end of the year, and contains 241 pages and thirty-five plates. It includes continuations of the Monographs of Cretaceous Lamellibranchs, Carboniferous Lamellibranchs, Carboniferous Cephalopods of Ireland, and British Carboniferous Ganoid Fishes, besides the first part of the long-expected Monograph of British Graptolites edited by Professor Lapworth.

All these Monographs are still in active progress, and further instalments of most of them may be expected to appear in the volume for 1902. This volume will also comprise the first part of the Secretary's new Monograph of the Fossil Fishes of the English Chalk, and a Monograph of the Cave Hyæna by Professor S. H. Reynolds. Thanks are due to the Geological Society for permission both to store the stock of back volumes, and to hold the Council meetings and the annual general meeting in their apartments.

In conclusion, it is proposed that the retiring members of the Council be Sir Archibald Geikie, Professor T. Rupert Jones, Dr. C. H. Gatty, and Mr. A. Strahan; that the new members be Miss Margaret Crosfield, Professor Charles Lapworth, Mr. A. M. Bell, and Mr. W. P. D. Stebbing; that the President be Dr. Henry Woodward; the new Vice-Presidents be Professor Lapworth and Rev. Dr. Wiltshire; the Treasurer, Mr. R. Etheridge; and the Secretary, Dr. A. Smith Woodward.

Annexed is the Balance Sheet.

THE PALÆONTOGRAPHICAL SOCIETY IN ACCOUNT WITH ROBERT ETHERIDGE, ESQ., TREASURER.

Cr. *Year ending March 31st*, 1902. *Dr.*

Cr.	£	s.	d.	Dr.	£	s.	d.
Balance from last Account—				Letterpress printing, binding, and distribution	151	11	0
On Deposit	700	0	0	Lithographic printing	113	9	8
Current Account	305	19	11	Paper	32	15	3
Subscriptions—1 for 1881	1	1	0	Drawing illustrations	126	7	6
,, 1 ,, 1895	1	1	0	Secretary's honorarium	52	10	0
,, 1 ,, 1898	1	1	0	Postage and stationery	8	10	4
,, 2 ,, 1899	2	2	0	Fire Insurance	0	15	0
,, 13 ,, 1900	13	13	0	Cheques, bank charges, and discounts	0	18	4
,, 172 ,, 1901	180	12	0	Audit of stock	2	2	0
,, 227 ,, 1902	238	7	0	Balance at Bank—			
417				On Deposit	900	0	0
Carriage paid by Foreign Members	1	0	4	Current Account	227	2	2
Donation	25	4	0				
Sales by Messrs. Dulau & Co.	146	0	0				
	£1616	1	3		£1616	1	3

Examined, with vouchers produced, and found correct.

JOHN HOPKINSON,
F. A. BATHER,
E. G. GARWOOD.

June 11*th*, 1902.

LIST OF MEMBERS.*

CORRECTED TO 1st NOVEMBER, 1902.

His Most Gracious Majesty the King.

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* The Members are requested to inform the Secretary of any errors or omissions in this list, and of any delay in the transmission of the Yearly Volumes.

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Liverpool, Athenæum Library.
Liverpool, Free Public Library.
Liverpool, Geological Society of.
Liverpool, Royal Institution.

Lomas, Joseph, Esq., F.G.S., *Local Secretary*, 13, Moss Grove, Birkenhead.
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London, British Museum (Nat. Hist.), Cromwell Road. S.W.
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CATALOGUE OF THE CONTENTS OF THE ANNUAL VOLUMES

ALREADY PUBLISHED BY

THE PALÆONTOGRAPHICAL SOCIETY.

Vol. I. Issued for the Year	1847	The Crag Mollusca, Part I, Univalves, by Mr. S. V. Wood (pp. i—xii, 1—208, pls. i—xxi, and title-page).
„ II. „	1848	The Reptilia of the London Clay, Vol. I, Part I, Chelonia, &c., by Profs. Owen and Bell (pp. 1—76, pls. i—xxviii, viii A, x A, xiii A, xvi A, xviii A, xix*, xix B, xix C, xix D).
		The Eocene Mollusca, Part I, Cephalopoda, by Mr. F. E. Edwards (pp. 1—56, pls. i—ix).
„ III.[1] „	1849	The Entomostraca of the Cretaceous Formations, by Mr. T. R. Jones (pp. 1—40, pls. i—vii).
		The Permian Fossils, by Prof. Wm. King (pp. i—xxxviii, 1—258, pls. i—xxviii*).
		The Reptilia of the London Clay, Vol. I, Part II, Crocodilia and Ophidia, &c., by Prof. Owen (pp. 1—68, pls. xxix, i—xvi, ii A).
		The Fossil Corals, Part I, Crag, London Clay, Cretaceous, by Messrs. Milne Edwards and Jules Haime (pp. i—lxxxv, 1—72, pls. i—xi).
„ IV. „	1850	The Crag Mollusca, Part II, No. 1, by Mr. S. V. Wood (pp. 1—150, pls. i—xii).
		The Mollusca of the Great Oolite, Part I, Univalves, by Messrs. Morris and Lycett (pp. i—viii, 1—130, pls. i—xv).
		The Fossil Brachiopoda, Vol. I, Part III, No. 1, Oolitic and Liassic, by Mr. Davidson (pp. 1—64, pls. i—xiii).
„ V. „	1851	The Reptilia of the Cretaceous Formations, by Prof. Owen (pp. 1—118, pls. i—xxxvii, vii A, ix A).
		The Fossil Corals, Part II, Oolitic, by Messrs. Milne Edwards and Jules Haime (pp. 73—146, pls. xii—xxx).
		The Fossil Lepadidæ, by Mr. Charles Darwin (pp. i—vi, 1—88, pls. i—v).
„ VI. „	1852	The Fossil Corals, Part III, Permian and Mountain-limestone, by Messrs. Milne Edwards and Jules Haime (pp. 147—210, pls. xxxi—xlvi).
		The Fossil Brachiopoda, Vol. I, Part I, Tertiary, by Mr. Davidson (pp. 1—23, pls. i, ii).
		The Fossil Brachiopoda, Vol. I, Part II, No. 1, Cretaceous, by Mr. Davidson (pp. 1—54, pls. i—v).
		The Fossil Brachiopoda, Vol. I, Part III, No. 2, Oolitic, by Mr. Davidson (pp. 65—100, pls. xiv—xviii).
		The Eocene Mollusca, Part II, Pulmonata, by Mr. F. E. Edwards (pp. 57—122, pls. x—xv).
		The Echinoderms of the Crag, London Clay, &c., by Prof. E. Forbes (pp. i—viii, 1—36, pls. i—iv, and title-page).
„ VII. „	1853	The Fossil Corals, Part IV, Devonian, by Messrs. Milne Edwards and Jules Haime (pp. 211—244, pls. xlvii—lvi).
		The Fossil Brachiopoda, Introduction to Vol. I, by Mr. Davidson (pp. 1—136, pls. i—ix).
		The Mollusca of the Chalk, Part I, Cephalopoda, by Mr. D. Sharpe (pp. 1—26, pls. i—x).
		The Mollusca of the Great Oolite, Part II, Bivalves, by Messrs. Morris and Lycett (pp. 1—80, pls. i—viii).
		The Mollusca of the Crag, Part II, No. 2, Bivalves, by Mr. S. V. Wood (pp. 151—216, pls. xiii—xx).
		The Reptilia of the Wealden Formations, Part I, Chelonia, by Prof. Owen (pp. 1—12, pls. i—ix).

[1] The Volume for the year 1849 consists of two separate portions, each of which is stitched in a paper cover, on which are printed the dates 1848, 1849, and 1850. The one portion contains 'Cretaceous Entomostraca' and 'Permian Fossils;' the other 'London Clay Reptilia,' Part II, and 'Fossil Corals,' Part I.

CATALOGUE OF VOLUMES—Continued.

Vol. VIII.[1]	Issued for the Year 1854	The Fossil Brachiopoda, Vol. I, Part II, No. 2, Cretaceous (pp. 55—117, pls. vi—xii), with Appendix and Index to Vol. I, by Mr. Davidson (pp. 1—30, pl. A).
		The Reptilia of the Wealden Formations, Part II, Dinosauria, by Prof. Owen (pp 1 —54, pls. i—xix, xvi A).
		The Mollusca of the Great Oolite, Part III, Bivalves, by Messrs. Morris and Lycett (pp 81—147, pls. ix—xv).
		The Fossil Corals, Part V, Silurian, by Messrs. Milne Edwards and Jules Haime (pp. 245—322, pls. lvii—lxxii).
		The Fossil Balanidæ and Verrucidæ, by Mr. Charles Darwin (pp. 1—44, pls. i, ii).
		The Mollusca of the Chalk, Part II, Cephalopoda, by Mr. D. Sharpe (pp. 27—36, pls. xi—xvi).
		The Eocene Mollusca, Part III, No. 1, Prosobranchiata, by Mr. F. E. Edwards (pp. 123—180, pls. xvi—xxiii).
„ IX.[2]	„ 1855	The Mollusca of the Crag, Part II, No. 3, Bivalves, by Mr. S. V. Wood (pp. 217—342, pls. xxi—xxxi).
		The Reptilia of the Wealden Formations, Part III, by Prof. Owen (pp. 1—26, pls. i—xii).
		The Eocene Mollusca, Part III, No. 2, Prosobranchiata, continued, by Mr. F. E. Edwards (pp. 181—240, pls. xxiv—xxvii).
		The Mollusca of the Chalk, Part III, Cephalopoda, by Mr. D. Sharpe (pp. 37—68, pls. xvii—xxvii).
		The Tertiary Entomostraca, by Mr. T. R. Jones (pp. i—xii, 1—68, pls. i—vi).
		The Fossil Echinodermata, Oolitic, Vol. I, Part I, by Dr. Wright (pp. v—x, 1—154, pls. i—x).
„ X.	„ 1856	The Fossil Echinodermata, Oolitic, Vol. I, Part II, by Dr. Wright (pp. 155—302, pls. xi—xxii).
		The Fossil Crustacea, Part I, London Clay, by Prof. Bell (pp. i—viii, 1—44, pls. i—xi).
		The Fossil Brachiopoda, Vol. II, Part IV, Permian, by Mr. Davidson (pp. 1—51, pls. i—iv).
		The Fossil Brachiopoda, Vol. II, Part V, No. 1, Carboniferous, by Mr. Davidson (pp. 1—48, pls. i—viii).
		The Reptilia of the Wealden Formations, by Prof. Owen, Part IV (pp. 8—26, pls. iv—xi), and Supplement No. 1 (pp. 1—7, pls. i—iii).
		The Reptilia of the London Clay, Vol. I (Supplement), by Prof. Owen (pp. 77—79, pls. xxviii A, xxviii B).
„ XI.	„ 1857	The Fossil Echinodermata, Oolitic, Vol. I, Part III, by Dr. Wright (pp. 303—390, pls. xxiii—xxxvi).
		The Fossil Brachiopoda, Vol. II, Part V, No. 2, Carboniferous, by Mr. Davidson (pp. 49—80, pls. ix—xvi).
		The Reptilia of the Cretaceous Formations (Supplement No. 1), by Prof. Owen (pp. 1—19, pls. i—iv).
		The Reptilia of the Wealden Formations (Supplement No. 2), by Prof. Owen (pp. 20—44, pls. v—xii.)
		The Polyzoa of the Crag, by Prof. Busk (pp. i—xiv, 1—136, pls. i—xxii).
„ XII.	„ 1858	The Fossil Echinodermata, Oolitic, Vol. I, Part IV, by Dr. Wright (pp. 391—468, pls. xxxvii—xliii).
		The Eocene Mollusca, Part III, No. 3, Prosobranchiata continued, by Mr. F. E. Edwards (pp. 241—330, pls. xxviii—xxxiii).
		The Reptilia of the Cretaceous Formations (Supplements No. 2, No. 3), by Prof. Owen (pp. 27—30, pl. vii, pp. 1—25, pls. i—vi).
		The Reptilia of the Purbeck Limestones, by Prof. Owen (pp. 31—39, pl. viii).
		The Fossil Brachiopoda, Vol. II, Part V, No. 3, Carboniferous by Mr. Davidson (pp. 81—120, pls. xvii—xxvi.
„ XIII.	„ 1859	The Fossil Brachiopoda, Part V, No. 4, Carboniferous, by Mr. Davidson (pp. 121—210, pls. xxvii—xlvii).
		The Reptilia of the Oolitic Formations, No. 1, Lower Lias, by Prof. Owen (pp. 1—14, pls. i—vi).
		The Reptilia of the Kimmeridge Clay, No. 1, by Prof. Owen (pp. 15, 16, pl. vii).
		The Eocene Mollusca, Part IV, No. 1, Bivalves, by Mr. S. V. Wood (pp. 1—74, pls. i—xiii).

[1] This Volume is marked on the outside 1855.
[2] This Volume is marked on the outside 1856.

CATALOGUE OF VOLUMES—Continued.

Vol.	Issued for the Year	Contents
Vol. XIV.	Issued for the Year 1860	The Fossil Brachiopoda, Vol. II, Part V, No. 5, Carboniferous, by Mr. Davidson (pp. 211—280, pls. xlviii—lv). The Reptilia of the Oolitic Formations, No. 2, Lower Lias, by Prof. Owen (pp. 1—26, pls. i—xi). The Reptilia of the Kimmeridge Clay, No. 2, by Prof. Owen (pp. 27, 28, pl. xii). The Fossil Estheriæ, by Prof. Rupert Jones (pp. i—x, 1—134, pls. i—v). The Fossil Crustacea, Part II, Gault and Greensand, by Prof. Bell (pp. i—vii, 1—40, pls. i—xi).
„ XV.	„ 1861	The Fossil Echinodermata, Oolitic, Vol. II, Part I (Asteroidea), by Dr. Wright (pp. 1—130, pls. i—x, x A, xi, xii). Supplement to the Great Oolite Mollusca, by Dr. Lycett (pp. 1—129, pls. xxxi—xlv).
„ XVI.	„ 1862	The Fossil Echinodermata, Cretaceous, Vol. I, Part I, by Dr. Wright (pp. 1—64, pls. i—iii, iii A, iv—vii, vii A, viii, xi). The Trilobites of the Silurian, Devonian, &c., Formations, Part I (Devonian and Silurian), by Mr. J. W. Salter (pp. 1—80, pls. i—vi). The Fossil Brachiopoda, Vol. III, Part VI, No. 1, Devonian, by Mr. Davidson (pp. 1—56, pls. i—ix). The Eocene Mollusca, Part IV, No. 2, Bivalves, by Mr. S. V. Wood (pp. 75—136, pls. xiv—xx). The Reptilia of the Cretaceous and Wealden Formations (Supplement, No. 4), by Prof. Owen (pp. 1—18, pls. i—ix).
„ XVII.	„ 1863	The Trilobites of the Silurian, Devonian, &c., Formations, Part II, by Mr. J. W. Salter (pp. 81—128, pls. vii—xiv). The Fossil Brachiopoda, Vol. III, Part VI, No. 2, Devonian, by Mr. Davidson (pp. 57—131, pls. x—xx). The Belemnitidæ, Part I, Introduction, by Prof. Phillips (pp. 1—28). The Reptilia of the Liassic Formations, Part I, by Prof. Owen (pp. 1—40, pls. i—xvi).
„ XVIII.	„ 1864	The Fossil Echinodermata, Oolitic, Vol. II, Part II (Liassic Ophiuroidea), by Dr. Wright (131—154, pls. xiii—xviii). The Trilobites of the Silurian, Devonian, &c., Formations, Part III, by Mr. J. W. Salter (pp. 129—176, pls. xv—xxv). The Belemnitidæ, Part II, Liassic Belemnites, by Prof. Phillips (pp. 29–52, pls. i—vii). The Pleistocene Mammalia, Part I, Introduction, Felis spelæa, by Messrs. W. Boyd Dawkins and W. A. Sanford (pp. i—l, 1—28, pls. i—v). Title-pages, &c., to the Monographs on the Reptilia of the London Clay, Cretaceous, and Wealden Formations.
„ XIX.[1]	„ 1865	The Crag Foraminifera, Part I, by Messrs. T. Rupert Jones, W. K. Parker, and H. B. Brady (pp. i—vi, 1—72, pls. i—iv). Supplement to the Fossil Corals, Part I, Tertiary, by Dr. Duncan (pp. i—iii, 1—66, pls. i—x). The Fossil Merostomata, Part I, Pterygotus, by Mr. H. Woodward (pp. 1—44, pls. i—ix). The Fossil Brachiopoda, Vol. III, Part VII, No. 1, Silurian, by Mr. Davidson (pp. 1—88, pls. i—xii).
„ XX.[1]	„ 1866	Supplement to the Fossil Corals, Part IV, No. 1, Liassic, by Dr. Duncan (pp. i—iii, 1—44, pls. i—xi). The Trilobites of the Silurian, Devonian, &c., Formations, Part IV (Silurian), by Mr. J. W. Salter (pp. 177—214, pls. xxv*—xxx). The Fossil Brachiopoda, Vol. III, Part VII, No. 2, Silurian, by Mr. Davidson (pp. 89—168, pls. xiii—xxii). The Belemnitidæ, Part III, Liassic Belemnites, by Prof. Phillips (pp. 53—88, pls. viii—xx).
„ XXI.[1]	„ 1867	Flora of the Carboniferous Strata, Part I, by Mr. E. W. Binney (pp. 1—32, pls. i—vi). Supplement to the Fossil Corals, Part IV, No. 2, Liassic, by Dr. Duncan (pp. 45—73, pls. xii—xvii). The Fossil Echinodermata, Cretaceous, Vol. I, Part II, by Dr. Wright (pp. 65—112, pls. ix, x, xii—xxi, xxi A, xxi B). The Fishes of the Old Red Sandstone, Part I, by Messrs. J. Powrie and E. Ray Lankester (pp. 1—32, pls. i—v). The Pleistocene Mammalia, Part II, Felis spelæa, continued, by Messrs. W. Boyd Dawkins and W. A. Sanford (pp. 29—124, pls. vi—xix).

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„ XXVI.[1]	„ 1872	Supplement to the Fossil Corals, Part III (Oolitic), by Prof. Duncan (pp. 1—24, pls. i—vii), with an Index to the Tertiary and Secondary Species. The Fossil Echinodermata, Cretaceous, Vol. I, Part V, by Dr. Wright (pp. 161—184, pls. xl—xliv). The Fossil Merostomata, Part IV (Stylonurus, Eurypterus, Hemiaspis), by Mr. H. Woodward (pp. 121—180, pls. xxi—xxx). The Fossil Trigoniæ, No. I, by Dr. Lycett (pp. 1—52, pls. i—ix).

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„ XXVIII.[1]	„ 1874	The Post-Tertiary Entomostraca, by Mr. G. S. Brady, Rev. H. W. Crosskey, and Mr. D. Robertson (pp. i—v, 1—232, pls. i—xvi). The Carboniferous Entomostraca, Part I (Cypridinidæ), by Prof. T. Rupert Jones and Messrs. J. W. Kirkby and G. S. Brady (pp. 1—56, pls. i—v). The Fossil Trigoniæ, No. II, by Dr. Lycett (pp. 53—92, pls. x—xix).
„ XXIX.[1]	„ 1875	The Flora of the Carboniferous Strata, Part IV, by Mr. E. W. Binney (pp. 97—147, pls. xix—xxiv). The Fossil Echinodermata, Cretaceous, Vol. I, Part VII, by Dr. Wright (pp. 225—264, pls. liii—lxii). The Fossil Trigoniæ, No. III, by Dr. Lycett (pp. 93—148, pls. xx—xxvii). The Fossil Reptilia of the Mesozoic Formations, Part II, by Prof. Owen (pp. 15—94, pls. iii—xxii).
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„ XXXII.[1]	„ 1878	The Fossil Echinodermata, Cretaceous, Vol. I, Part VIII, by Dr. Wright (pp. 265—300, pls. lxii A, lxiii—lxix). Index and Title Page to the Fossil Echinodermata, Oolitic, Vol. I (Echinoidea), by Dr. Wright (pp. 469—481). The Fossil Merostomata, Part V (Neolimulus, &c.), by Dr. H. Woodward (pp. 181—263, pls. xxxi—xxxvi, and title-page). Supplement to the Fossil Brachiopoda, Vol. IV, Part II, No. 2 (Jurassic and Triassic), by Mr. Davidson (pp. 145—242, pls. xvii—xxix). The Lias Ammonites, Part I, by Dr. Wright (pp. 1—48, pls. i—viii). The Sirenoid and Crossopterygian Ganoids, Part I, by Prof. Miall (pp. 1—32, pls. i, i A, ii—v). Supplement to the Reptilia of the Wealden (Goniopholis, Petrosuchus, and Suchosaurus), No. VIII, by Prof. Owen (pp. 1—15, pls. i—vi). The Pleistocene Mammalia, Part A (Preliminary Treatise), by Prof. Boyd Dawkins (pp. i—xxxviii).

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„ XXXVI.[1]	„ 1882	The Eocene Flora, Vol. I, Part III, by Mr. J. S. Gardner and Baron Ettingshausen (pp. 59—86, pls. xii, xiii, and title-page). Third Supplement to the Crag Mollusca, by the late Mr. S. V. Wood (pp. 1—24, pl. i). The Fossil Echinodermata, Cret., Vol. I, Part X, by Dr. Wright (pp. 325—371, pls. lxxvi—lxxx, and title-page). Supplement to the Fossil Brachiopoda, Vol. IV, Part V, by Dr. Davidson (pp. 369—383, and title-page). Do., Vol. V, Part I (Devonian and Silurian), by Dr. Davidson (pp. 1—134, pls. i—vii). The Lias Ammonites, Part V, by Dr. Wright (pp. 329—400, pls. xlix—lii, lii A, liii—lxix).
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- The Lias Ammonites, Part VIII, by the late Dr. Wright (pp. 481—503, pl. lxxxviii, and title-page).

„ XL.[1] „ 1886
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- The Jurassic Gasteropoda, Part I, No. 1, by Mr. W. H. Hudleston (pp. 1—56).
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- The Pleistocene Mammalia, Part VI, by Prof. Boyd Dawkins (pp. 1—29, pls. i—vii).

„ XLI.[1] „ 1887
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- The Inferior Oolite Ammonites, Part II, by Mr. S. S. Buckman (pp. 25—56, pls. vii—xiv).

„ XLII.[1] „ 1888
- The Stromatoporoids, Part II, by Prof. Alleyne Nicholson (pp. 131—158, pls. xii—xix).
- The Tertiary Entomostraca (Supplement), by Prof. T. Rupert Jones and Mr. C. D. Sherborn (pp. 1—55, pls. i—iii).
- The Jurassic Gasteropoda, Part I, No. 3, by Mr. W. H. Hudleston (pp. 137—192, pls. vii—xi).
- The Inferior Oolite Ammonites, Part III, by Mr. S. S. Buckman (pp. 57—144, pls. xv xxiii A).
- The Devonian Fauna of the South of England, Part I, by the Rev. G. F. Whidborne (pp. i, ii, 1—46, pls. i—iv).
- Title-pages and Prefaces to the Monographs on the Reptilia of the Wealden and Purbeck (Supplements), Kimmeridge Clay, and Mesozoic Formations, and on the Cetacea of the Red Crag.

„ XLIII.[1] „ 1889
- The Cretaceous Entomostraca (Supplement), by Prof. T. Rupert Jones and Dr. G. J. Hinde (pp. i—viii, 1—70, pls. i—iv).
- The Jurassic Gasteropoda, Part I, No. 4, by Mr. W. H. Hudleston (pp. 193—224, pls. xii—xvi).
- The Inferior Oolite Ammonites, Part IV, by Mr. S. S. Buckman (pp. 145—224, pls. xxiv—xxxvi).
- The Devonian Fauna of the South of England, Part II, by the Rev. G. F. Whidborne (pp. 47—154, pls. v—viii, viii A, ix—xv).

„ XLIV.[1] „ 1890
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- The Inferior Oolite Ammonites, Part V, by Mr. S. S. Buckman (pp. 225—256, pls. xxxvii—xliv).
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- Title-pages to the Supplement to the Fossil Corals, by Prof. Duncan.

„ XLV.[1] „ 1891
- The Jurassic Gasteropoda, Part I, No. 5, by Mr. W. H. Hudleston (pp. 225—272, pls. xvii—xxi).
- The Inferior Oolite Ammonites, Part VI, by Mr. S. S. Buckman (pp. 257—312, pls. xlv—lvi).
- The Devonian Fauna of the South of England, Part IV (*Conclusion of* Vol. I) (pp. 251—344, pls. xxv—xxxi, and title-page).
- „ „ Vol. II, Part I, by the Rev. G. F. Whidborne (pp. 1—56, pls. i—v).

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„ XLVII.[1]	„ 1893	The Fossil Sponges, Part III, by Dr. G. J. Hinde (pp. 189—254, pls. x—xix). The Fossil Echinodermata, Cretaceous, Vol. II, Part II (Asteroidea), by Mr. W. Percy Sladen (pp. 29—66, pls. ix—xvi). The Inferior Oolite Ammonites, Part VIII, by Mr. S. S. Buckman (pp. 345—376, pls. lxxvii—xcii). The Devonian Fauna of the South of England, Vol. II, Part III, by the Rev. G. F. Whidborne (pp. 89—160, pls. xi—xvii).
„ XLVIII.[1]	„ 1894	The Jurassic Gasteropoda, Part I, No. 7, by Mr. W. H. Hudleston (pp. 325—390, pls. xxvii—xxxii). Carbonicola, Anthracomya, and Naiadites, Part I, by Dr. W. Hind (pp. 1—80, pls. i—xi). The Inferior Oolite Ammonites, Part IX, by Mr. S. S. Buckman (pp. 377—456, pls. xciii—ciii). The Fishes of the Old Red Sandstone, Part II, No. 1, by Dr. R. H. Traquair (pp. 63—90, pls. xv—xviii).
„ XLIX.[1]	„ 1895	The Crag Foraminifera, Part II, by Prof. T. R. Jones (pp. 73—210, pls. v—vii). The Jurassic Gasteropoda, Part I, No. 8, by Mr. W. H. Hudleston (pp. 391—444, pls. xxxiii—xl). Carbonicola, Anthracomya, and Naiadites, Part II, by Dr. W. Hind (pp. 81—170, pls. xii—xx). The Devonian Fauna of the South of England, Vol. II, Part IV, by the Rev. G. F. Whidborne (pp. 161—212, pls. xviii—xxiv).
„ L.[1]	„ 1896	The Crag Foraminifera, Part III, by Prof. T. R. Jones (pp. 211—314). The Jurassic Gasteropoda, Part I, No. 9, by Mr. W. H. Hudleston (pp. 445—514, pls. xli—xliv, and title-page). Carbonicola, Anthracomya, and Naiadites, Part III, by Dr. W. Hind (pp. 171—182, pl. xxi, and title-page). The Carboniferous Lamellibranchiata, Part I, by Dr. W. Hind (pp. 1—80, pls. i, ii). The Devonian Fauna of the South of England, Vol. III, Part I, by the Rev. G. F. Whidborne (pp. 1—112, pls. i—xvi).
„ LI.[1]	„ 1897	The Crag Foraminifera, Part IV, by Prof. T. R. Jones (pp. vii—xv, 315—402, and title-page). The Carboniferous Lamellibranchiata, Part II, by Dr. W. Hind (pp. 81—208, pls. iii—xv). The Carboniferous Cephalopoda of Ireland, Part I, by Dr. A. H. Foord (pp. 1—22, pls. i—vii). The Devonian Fauna of the South of England, Vol. III, Part II, by the Rev. G. F. Whidborne (pp. 113—178, pls. xvii—xxi).
„ LII.[1]	„ 1898	The Palæozoic Phyllopoda, Part III, by Prof. T. R. Jones and Dr. Woodward (pp. 125—176, pls. xviii—xxv). The Carboniferous Lamellibranchiata, Part III, by Dr. W. Hind (pp. 209—276, pls. xvi—xxv). The Inferior Oolite Ammonites, Part X, by Mr. S. S. Buckman (pp. i—xxxii, Suppl. pls. i—iv). The Carboniferous Cephalopoda of Ireland, Part II, by Dr. A. H. Foord (pp. 23—48, pls. viii—xvii). The Devonian Fauna of the South of England, Vol. III, Part III, by the Rev. G. F. Whidborne (pp. 179—236, pls. xxii—xxxviii).

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„ LIV.[1]	„ 1900	The Cretaceous Lamellibranchia, Part II, by Mr. H. Woods (pp. 73—112, pls. xv—xix). The Carboniferous Lamellibranchiata, Part V, by Dr. W. Hind (pp. 361—476, pls. xl—liv). The Carboniferous Cephalopoda of Ireland, Part III, by Dr. A. H. Foord (pp. 49—126, pls. xviii—xxxii). The British Pleistocene Mammalia, Title-page for Vol. I, by Messrs. Dawkins and Sanford. The Structure of Carboniferous Plants, Title-page, by Mr. E. W. Binney.
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,,	II	,,	1848	,,	,,	,,		July, 1849.
,,	III	,,	1849	,,	,,	,,		August, 1850.
,,	IV	,,	1850	,,	,,	,,		June, 1851.
,,	V	,,	1851	,,	,,	,,		June, 1851.
,,	VI	,,	1852	,,	,,	,,		August, 1852.
,,	VII	,,	1853	,,	,,	,,		December, 1853.
,,	VIII	,,	1854	,,	,,	,,		May, 1855.
,,	IX	,,	1855	,,	,,	,,		February, 1857.
,,	X	,,	1856	,,	,,	,,		April, 1858.
,,	XI	,,	1857	,,	,,	,,		November, 1859.
,,	XII	,,	1858	,,	,,	,,		March, 1861.
,,	XIII	,,	1859	,,	,,	,,		December, 1861.
,,	XIV	,,	1860	,,	,,	,,		May, 1863.
,,	XV	,,	1861	,,	,,	,,		May, 1863.
,,	XVI	,,	1862	,,	,,	,,		August, 1864.
,,	XVII	,,	1863	,,	,,	,,		June, 1865.
,,	XVIII	,,	1864	,,	,,	,,		April, 1866.
,,	XIX	,,	1865	,,	,,	,,		December, 1866.
,,	XX	,,	1866	,,	,,	,,		June, 1867.
,,	XXI	,,	1867	,,	,,	,,		June, 1868.
,,	XXII	,,	1868	,,	,,	,,		February, 1869.
,,	XXIII	,,	1869	,,	,,	,,		January, 1870.
,,	XXIV	,,	1870	,,	,,	,,		January, 1871.
,,	XXV	,,	1871	,,	,,	,,		June, 1872.
,,	XXVI	,,	1872	,,	,,	,,		October, 1872.
,,	XXVII	,,	1873	,,	,,	,,		February, 1874.
,,	XXVIII	,,	1874	,,	,,	,,		July, 1874.
,,	XXIX	,,	1875	,,	,,	,,		December, 1875.
,,	XXX	,,	1876	,,	,,	,,		December, 1876.
,,	XXXI	,,	1877	,,	,,	,,		February, 1877.
,,	XXXII	,,	1878	,,	,,	,,		March, 1878.
,,	XXXIII	,,	1879	,,	,,	,,		May, 1879.
,,	XXXIV	,,	1880	,,	,,	,,		May, 1880.
,,	XXXV	,,	1881	,,	,,	,,		May, 1881.
,,	XXXVI	,,	1882	,,	,,	,,		June, 1882.
,,	XXXVII	,,	1883	,,	,,	,,		October, 1883.
,,	XXXVIII	,,	1884	,,	,,	,,		December, 1884
,,	XXXIX	,,	1885	,,	,,	,,		January, 1886.
,,	XL	,,	1886	,,	,,	,,		March, 1887.
,,	XLI	,,	1887	,,	,,	,,		January, 1888.
,,	XLII	,,	1888	,,	,,	,,		March, 1889.

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,,	LI	,,	1897	,,	,,	December, 1897.
,,	LII	,,	1898	,,	,,	December, 1898.
,,	LIII	,,	1899	,,	,,	December, 1899.
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OF THE

BRITISH PLEISTOCENE MAMMALIA

VOL. II, PART I.

THE CAVE HYÆNA.

BY

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MONOGRAPH

ON

THE BRITISH MAMMALIA

OF THE

PLEISTOCENE PERIOD.

THE CAVE HYÆNA.

Order—CARNIVORA.

FAMILY—HYÆNIDÆ.

Genus—HYÆNA.

Species—*Hyæna crocuta*, Erxleben.

I. HISTORICAL INTRODUCTION.

THE early history of the recognition of remains of the hyæna in Europe is dealt with by Cuvier, and much use has been made of his account in the following pages.

The first evidence for their occurrence is afforded by a figure of part of the right mandibular ramus given by Kundmann in his 'Rariora Naturæ et Artis,' published in Breslau in 1737. He regarded this as similar to that of a calf, but its hyænine nature was recognised by Cuvier.

Thirty-seven years later (1774), Esper figured bones from Gailenreuth—an atlas which he regarded as hyænine, but which Cuvier says is that of a bear,—and some teeth, which he regarded as belonging to a lion, but which Cuvier says are hyænine.

Again, in 1784, Collini gave an excellent figure of a hyæna skull found near Mannheim. Unfortunately, however, he was disposed to regard it as perhaps that of a seal.

The first full account of the cave hyæna was that given by G. Cuvier in 1812.[1] He mentioned a number of Continental localities in which bones of hyænas had been found, and considered that the fossil hyæna was distinct from any living species, basing his opinion at that time mainly on the great size of many of the fossil bones.

The occurrence of the cave hyæna in England was first clearly established by Dean Buckland in his account of the Kirkdale Cave.[2] The full title of this important paper, which was published in 1822, is "Account of an Assemblage of Fossil Teeth and Bones of Elephant, Rhinoceros, Hippopotamus, Bear, Tiger, Hyæna, and sixteen other Animals discovered in a Cave at Kirkdale, Yorks, in the year 1821, with a Comparative View of five similar Caverns in various parts of England, and others on the Continent." In this paper, and in his 'Reliquiæ Diluvianæ' (1824), he clearly showed that the caves in which the hyæna bones were found were the actual dens of the animals.

Buckland's discovery of hyæna remains at Kirkdale was closely followed by Clift and Whidbey's discovery of them at Oreston, near Plymouth.[3]

Goldfuss,[4] writing in 1823, was the first to apply the distinctive name *Hyæna spelæa* to the cave hyæna. He gave a detailed comparison with figures and measurements of the bones of the cave species and of the spotted hyæna.

In the second edition of the 'Ossemens Fossiles' (1823), Cuvier, in giving a further account of the cave hyæna, referred specially to what he held to be the differences between it and the spotted hyæna, and mentioned, with regard to the metacarpals and metatarsals, that all the bones measured were, without exception, shorter and thicker in the cave hyæna than in the spotted hyæna. With regard to the teeth, however, the general tendency of his remarks implies that it is impossible to distinguish those of the one from those of the other.

Meanwhile the discovery and study of hyæna remains were actively pursued on the Continent, and a number of new species of hyæna, some allied to the living *H. crocuta* and some to the living *H. striata*, were described by Croizet and Jobert[5] (1828), and by Marcel de Serres, Dubrueil, and Jeanjean[6] (1839). Throughout the first half of the nineteenth century little doubt apparently was felt by palæontologists that the cave hyæna was distinct from the spotted hyæna. Thus de Blainville[7] (1844), Pictet[8] (1844), and Owen[9] (1846) all accepted this view. De Blainville discusses the question in detail (*vide postea*), and bases his opinion mainly on the form of the upper molar.

The first palæontologist to express strong doubts as regards the specific distinction of the cave and the spotted hyænas was Gaudry[10] (1863), but Boyd Dawkins,[11] writing in 1865, was the first definitely to conclude that no distinction could be drawn between

[1] 'Oss. Foss.,' ed. 1, iv.
[2] 'Phil. Trans.,' cxii (1), p. 171.
[3] 'Phil. Trans.,' cxiii, p. 88.
[4] 'Saüg. Vorw.,' vi.
[5] 'Oss. Foss. Puy de Dôme.'
[6] 'Oss. Lunel Viel.'
[7] 'Ostéographie,' livr. 14.
[8] 'Traité Paléont.,' i, p. 180.
[9] 'Brit. Foss. Mamm.,' pp. 138—160.
[10] 'Bull. Soc. Géol. France' (2), xx, p. 404.
[11] 'Nat. Hist. Rev.,' n. s., v, p. 80.

H. spelæa and *H. crocuta*. He laid stress on the variable character of the tubercular portion of the lower carnassial, and considered that several of the supposed species that had been founded by Croizet and Jobert, and by de Serres, Dubrueil, and Jeanjean, mainly on variations in this tooth, were not valid, but were varieties of the cave hyæna (*vide postea*). In his paper on the mammal fauna of the Creswell Crags,[1] published in 1877, the same author says that, after comparison of the skulls of *H. crocuta* and *H. spelæa*, he has been unable to detect points of difference of specific value, and definitely states that he believes the two to be identical.

Busk, however, writing in the same year,[2] while recognising the close relationship between the two forms, said that he did not consider it proved that *H. spelæa* was a mere variety of *H. crocuta*.

Since the publication of Boyd Dawkins' paper in 1863, almost all authors have accepted the view of the identity of the two forms. This has been done, for example, by Newton[3] (1883), Lydekker[4] (1884–5), Forsyth Major[5] (1885), Woodward and Sherborn[6] (1890), Gaudry[7] (1892), and Zittel[8] (1893); so that the fact of their identity may be considered to be clearly established. Schlosser,[9] however, expresses doubt as to their identity, mainly on account of the geographical distribution of *H. crocuta* at the present day.

A later phase in the study of hyænas has been the discussion of the mutual relationships of the fossil forms, and the probable ancestry of the living ones. This subject has been most fully dealt with by Lydekker,[10] Schlosser,[9] and Gaudry.[7] Lydekker, basing his opinion largely on its occurrence in the Pleistocene Caves of Karnul, in the Madras Presidency, considers that *Hyæna crocuta* originated in India, being derived from the Siwalik (Lower Pliocene) *Hyæna Colvini*, Lyd. The lower carnassials of the two forms agree closely, especially as regards the development of the cingulum, differing chiefly in the relatively large development of the hind talon in *H. Colvini*. Schlosser derives the cave hyæna, and eventually *H. crocuta*, from the Upper Pliocene *H. Perrieri* of Croizet and Jobert. He derives *H. Perrieri* from an unknown form whose nearest ally was *H. sivalensis*, and he regards *H. Colvini* as altogether off the line of descent in question. Gaudry also derives *H. crocuta* (including the cave hyæna) from *H. Perrieri*, but expressly states that he has not taken account of the Indian species, not being personally acquainted with their fossil remains. The subject of the mutual relationship of the different species of hyæna lies, however, too much beyond the scope of the present monograph to be fully dealt with.

1 'Q. J. Geol. Soc.,' xxxiii, p. 596.
2 'Trans. Zool. Soc.,' x (2), p. 53.
3 'Geol. Mag.,' 1883, p. 433.
4 'Pal. Indica,' ser. 10, ii, p. 275; 'Catal. Foss. Mamm. Brit. Mus.,' i, p. 69.
5 'Q. J. Geol. Soc.,' xli, p. 1.
6 'Catal. Brit. Foss. Vert.'
7 'Matér. Hist. Temps Quat.' (4), p. 116.
8 'Handb. Palæont.,' iv, p. 661.
9 'Beitr. Pal. Österreich-Ungarns,' iii, p. 29.
10 'Pal. Indica,' ser. 10, ii, p. 310.

It may be well here to refer to the reported occurrence of hyænoid animals in North America. In his paper on "The Extinct Dogs of North America," 1883, Cope[1] described a form from the Upper Miocene beds of Nebraska and New Mexico, which he named *Ælurodon Wheelerianus.* He grouped this with the Canidæ, but nevertheless suspected it to be the ancestor of the Hyænidæ, a view which Schlosser[2] accepts, altering Cope's name to *Prohyæna.* In 1892, Cope[3] published a brief reference to a hyæna-like form from the Pliocene of Texas, which differed from *Hyæna* proper in having a fourth premolar in the lower jaw, and probably a shorter blade to the sectorial tooth of the upper jaw. He named this *Borophagus diversidens.* Lastly, in 1895, Cope[4] founded a new species of *Hyæna* (*H. inexpectata*) on a tooth from a fissure at Port Kennedy, Pennsylvania, which Lydekker[5] suggests may prove to belong to a *Nimravus*.

II. DISTRIBUTION IN BRITAIN AND ELSEWHERE.

While a number of Tertiary species of hyæna have been recognised on the Continent, only detached teeth of this genus have hitherto been discovered below the Forest Bed in Britain.[6] From the latter horizon, however, at Corton Cliff, Suffolk, hyæna remains were described by Newton[7] in 1883. These consist of the canine, and second, third, and fourth premolars, all from the upper jaw, and all clearly referable to *H. crocuta.* It is thus evident that the animal was an immigrant from the continent of Europe in Pliocene times. In this respect it resembles the cave bear and horse, with which its remains are often associated, and differs from the lion, which does not appear to have reached England till Pleistocene times.

In these times the hyæna was extremely plentiful in England. Its remains are not infrequent in river gravels, but its almost universal occurrence in cave deposits shows that in the Pleistocene period it was essentially a cave dweller as it is at the present time. The fact that these caves were the actual dens of the hyænas, in which they lived and died, is clear from the frequent occurrence of coprolites, of splintered and gnawed bones, and of the teeth of young individuals. Referring to the state of the bones in the Robin Hood Cave, Boyd Dawkins[8] says: "With few exceptions the solid bones are alone perfect, the long bones containing marrow, and the vertebræ being represented merely by gnawed fragments. All the lower jaws have lost their angles and coronoid processes, and the number of teeth stands in a greater ratio to the number of bones than would have been the case had not their possessors fallen a prey to a bone-

[1] 'Amer. Nat.,' xvii, p. 243.

[2] 'Beitr. Pal. Österreich-Ungarns,' iii, p. 25.

[3] 'Amer. Nat.,' xxvi, p. 1028.

[4] 'Proc. Ac. Nat. Sci. Philad.,' 1895, p. 446.

[5] 'Zool. Record,' 1895, p. 28.

[6] *Hyæna antiqua*, Lankester, 'Ann. Mag. Nat. Hist.,' ser. 3, vol. xiii, 1864, p. 56, pl. viii, figs. 5, 6, from Red Crag, Suffolk.

[7] 'Geol. Mag.,' 1883, p. 433.

[8] 'Q. J. Geol. Soc.,' xxxii, p. 245.

destroying animal." This description would apply equally well to the state of the bones in almost all the caves in which hyæna remains occur; and the fact that the bones of the hyæna itself are often found gnawed and splintered shows that the animal was sometimes compelled to feed on its own kind.

The following is a list of British localities in which remains of hyænas have been found. Boyd Dawkins[1] published a similar list in 1869, and the number of localities has not been much added to since that date.[2]

Caves and Fissures.—Bleadon, Somerset; Boughton fissure, Maidstone; Blackrock fissure, Tenby; Bench and other caves, Brixham; Burrington, Somerset; Calay Cave; Cae Gwyn, North Wales; Cefn, near St. Asaph; Cheddar; Coygau Cave, near Laugharne, Carmarthen; Creswell Caves, Derbyshire; Durdham Down, Bristol; Ffynnon Beuno, North Wales; Gower Caves (Bacon Hole, Cat's Hole, Caswell Bay, Crow Hole, Long Hole, Minchin Hole, Paviland, Ravenscliff, Spritsail Tor); Hutton, Somerset; Hoyle; Ightham fissure, Kent; Kirby Moorside; Kirkdale, Yorkshire; Oreston, Plymouth; Raygill fissure, Yorkshire; Sandford Hill, Somerset; Torquay (Kent's Hole and Tor Bryan); Uphill, Somerset; Victoria Cave, Settle; Wookey Hole, Somerset; Yealm Bridge, Devon.

While the majority of the above were caves of occupation, in some instances, such as Uphill, the bones occur in fissures whose connection with any cave of occupation, though probable, has not been proved. In such cases the bones were probably swept into the fissures by water action.

Localities other than Caves and Fissures.—Aymestry, Brentford, Dogger Bank, Erith, Fisherton near Salisbury, Grays, Lawford near Rugby, Maidstone, Walton in Essex, Weston-super-Mare, Yarmouth.

While at the present day *Hyæna crocuta* is found only in Africa south of the Sahara, it appears from the above lists that in Pleistocene times it ranged over England and Wales as far north as Yorkshire, not, however, reaching Scotland or Ireland. It has been recorded from caves over the whole of continental Europe, from Spain and Sicily to Poland. One of the most interesting records of the occurrence of the cave hyæna is that from the Karnul Caves in the Madras Presidency.[3] The importance lies in the fact that the area of distribution of the cave hyæna is thereby connected with that of the closely allied Pliocene crocutine hyænas, such as *H. Colvini*. Hence it becomes probable that it was in India that the cave hyæna originated, spreading thence into Europe in late Pliocene times.

For the purpose of the present monograph the bones found in the Somersetshire caves, and especially the very large series from Wookey Hole, preserved in the Taunton Museum, have proved most useful. The series includes two almost complete skeletons

[1] 'Quart. Journ. Geol. Soc.,' xxv, p. 194.

[2] See also Woodward and Sherborn, 'Catal. Brit. Foss. Vert.,' 1890, p. 354.

[3] Lydekker, 'Pal. Indica,' ser. 10, iv, p. 30.

composed of associated bones. These, which are here referred to as skeletons A and B, have furnished the great majority of the bones figured, and may be briefly described.

Skeleton A.—This includes the cranium (Pl. I, and Pl. II, fig. 1), of which the occipital region, sagittal crest, palatal plate, dentition of left side, and a considerable portion of the left zygomatic arch are well preserved. The mandible is missing. The vertebral column is nearly complete, lacking only the caudal vertebræ. The left scapula is fragmentary, but the right one is fairly well preserved, having the coracoid and glenoid borders unfortunately much broken. The right anterior limb is in a remarkably perfect state except for the loss of some of the small bones of the manus; but the left limb lacks the distal end of the ulna and the proximal end of the radius. The ribs and the sternum are wanting. Both ossa innominata are in a fairly perfect state (Pl. XII). The right posterior limb is complete except for the loss of some of the small bones of the pes; but the left fibula is wanting.

Skeleton B.—The skull (Pl. II, fig. 2) is nearly perfect, the mandible (Pl. III, figs. 2, 3) being associated with the cranium. The chief parts lacking are the zygomatic arches, and the incisors and canines of the upper jaw. The posterior end of the sagittal crest is damaged. The mandible lacks nearly all the incisor teeth, and has the left condylar region in a fragmentary state. The vertebral column lacks the first thoracic and the first and second lumbar, as well as the caudal vertebræ, but is otherwise in good condition. The left os innominatum is nearly complete, but the other parts of both limb girdles are in a fragmentary state. All the long bones of both anterior and posterior limbs are well preserved, except the left femur. The left fibula shows a growth of bone (exostosis) such as one generally meets with in menagerie skeletons.

The other bones and teeth figured are from the Creswell Caves, Derbyshire, the Tor Bryan Caves, Torquay, and Kirkdale Cave, Yorkshire. All measurements are given in centimetres.

In the preparation of this monograph I have received much kind help from Professor Boyd Dawkins, Mr. Sherborn, and Dr. Smith Woodward, and to them my best thanks are tendered. I am also greatly indebted to Mr. H. St. G. Gray, to Mr. Hoyle, and to Professor Sollas for facilities in the examination and figuring of specimens preserved in the Taunton Castle, Owens College, and Oxford University Museums; and finally to Mr. J. Green for the great amount of care and trouble he has taken in drawing eight of the plates.

III. DESCRIPTION OF THE REMAINS.

A. The Skull (Plates I, II, III).

(1) *Distinctive Features of the Skull in the Genus Hyæna.*—There are many noteworthy features in which the skull of *Hyæna* contrasts markedly with that of *Felis* and

Canis, nearly all of these features being noted many years ago by Cuvier[1] and de Blainville.[2] They may be summarised as follows:

The face is short, the cranium narrow behind the orbits and below the ears, giving rise to very wide and deep temporal fossæ. The mandible is even shorter than in *Felis*, and has the salient angle more marked. The sinuses are very large, occupying the whole sagittal crest from the frontal to the supra-occipital. They are large also in the occipital crest, which is formed by the supra-occipital without the addition of any interparietal. The sinuses in the occipital crest often have irregular openings to the surface. The auditory bulla is simple and undivided by a septum, in this respect differing from that of *Felis*. There is no alisphenoid canal. The pterygoid is prolonged into prominent, backwardly directed, and sometimes hooked processes. The post-glenoid process of the squamosal is better marked than in *Felis* and *Canis*. In some cases processes of the premaxillæ and frontals meet and separate the nasals from the maxillæ, while in most cases the nasals and maxillæ are in contact for a short space; in the genera *Felis* and *Canis* the nasals and maxillæ are united along a wide surface.

(2) *Differences between the Skull of the Living* Hyæna crocuta *and those of* Hyæna striata *and* Hyæna brunnea.—This subject was fully dealt with by Cuvier and de Blainville, and subsequently by Busk.[3] The points of difference are as follows:

1. The space partially enclosed between the truncated ends of the nasal bones is relatively wider, and its posterior opening is less acute in *H. crocuta* than in *H. striata*.
2. In *H. crocuta* the auditory bulla is considerably more inflated than in *H. striata*.
3. The mastoid process of the periotic is more compressed in *H. striata* than in *H. crocuta*.
4. The anterior palatine foramina are relatively larger in *H. striata* than in *H. crocuta*.
5. The rotundity and fulness of the parietal region of the skull is greater in *H. crocuta* than in *H. striata*.
6. The sagittal crest, as noted by Cuvier, is more compressed and distinct in *H. striata* than in *H. crocuta*.
7. The post-orbital process of the frontal is less prominent in *H. crocuta* than in *H. striata*.
8. The pterygoid process is narrower in *H. crocuta* than in *H. striata*.
9. The zygomatic arch is less arched in *H. crocuta* than in *H. striata*.
10. The angle of the mandible is more pronounced in *H. crocuta* than in *H. striata*.
11. The jawbones and zygomatic arch are thicker in *H. crocuta* than in *H. striata*.

[1] 'Oss. Foss.,' ed. 3, iv, p. 381.
[2] 'Ostéographie: Hyènes,' p. 10.
[3] 'Journ. Linn. Soc. (Zool.),' ix, p. 59.

(3) TABLE OF COMPARATIVE MEASUREMENTS OF HYÆNA SKULLS.

	H. striata, No. 136K (Brit. Mus.), from Karachi.	*H. crocuta*, 92.8.1.4 ♀ (Brit. Mus.), Nyassa.	*H. crocuta*, No. 523 (College of Surgeons).	*H. crocuta*, No. 524 (College of Surgeons).	*H. crocuta*, No. 522 (College of Surgeons).	*H. spelæa* = *crocuta* (skull A), Wookey (Taunton Museum), fig. Pl. I and II.	*H. spelæa* = *crocuta* (skull B), Wookey (Taunton Museum), fig. Pl. II.	*H. spelæa* = *crocuta*, Creswell (Owens College Mus.).	*H. spelæa* = *crocuta*, Creswell (Owens College Mus.).	*H. spelæa* = *crocuta*, No. 28558 (Brit. Mus.), Sundwig.	*H. spelæa* = *crocuta*, No. 28557 (Brit. Mus.), Sundwig.	*H. brunnea*, out of stuffed specimen, 53.3.11.1 (Brit. Mus.).	*H. striata*, Ngaputuh Mts., Vict. Nyanza, 6.5.12.1 (Brit. Mus.).
1. Length from intercondylar notch to anterior end of skull	20·0	24·7	23·6	22·55	22·3	24·65	24·7	22·5	...	25·6	...	...	20·1
2. Extreme width across zygomatic arches	15·2	17·6	17·65	16·75	18·05	...	. .	...	...	...	19·9	17·5	14·8
3. Vertical height from suture between basioccipital and basisphenoid to top of sagittal crest	7·8	9·8	9·95	9·3	9·6	10·95	10·35	9·5	7·9	11·6	10·7	9·1	8·1
4. Width immediately above lachrymal foramen	4·6	6·1	6·55	6·1	5·35	6·65	6·75	...	5·6	6·15	6·6	5·35	4·25
5. Width between ends of post-orbital processes............... ...	7·5	8·0	8·1	7·4	8·6	8·2	9·8	...	7·2	9·9	8·5	8·55	8·0
6. Width measured from alveolar borders immediately above last upper premolars	8·7	11·3	10·95	10·7	11·7	. .	12·6	...	...	12·7	12·4	9·7	8·15
7. Minimum width below foramen lacerum anterius	0·9	1·65	1·75	1·7	1·6	1·65	1·65	2·1	2·05	1·7	1·7	0·9	1·25
8. Diameter across occipital condyles ...	4·4	5·2	4·4	5·25	5·25	5·6	5·75	...	...	5·6	...	...	4·35
9. Transverse diameter of foramen magnum	1·9	...	1·7	2·25	2·1	2·1	2·2	...	...	2·0	...	...	2·0
10. Maximum diameter of anterior narial opening	2·4	3·3	2·7	2·8	2·8	3·4	3·2	...	...	...	3·2	2·4	2·15
11. Maximum length of right mandibular ramus	16·5	19·85	19·85	18·7	18·95	...	18·85	17·65 [1]	...	21·25	...	18·45	16·15
12. Transverse measurement of one condyle	3·25	4·6	4·6	4·1	4·45	...	4·4	3·2	4·1 [1]	5·05	...	4·4	3·2
13. Height from angle to top of coronoid process	6·35	8·9	8·7	8·2	8·05	...	8·75	...	...	9·9	...	8·3	7·05

[1] I am not aware whether these mandibles belong to the crania measured.

B. DENTITION (Plates IV, V).

(1) *Distinctive Features of the Teeth in the Genus Hyæna.*—The dental formula of *Hyæna* is i. $\frac{3}{3}$ c. $\frac{1}{1}$ pm. $\frac{4}{3}$ m. $\frac{1}{1}$, as compared with i. $\frac{3}{3}$ c. $\frac{1}{1}$ pm. $\frac{3}{2}$ m. $\frac{1}{1}$ in *Felis,* and i. $\frac{3}{3}$ c. $\frac{1}{1}$ pm. $\frac{4}{4}$ m. $\frac{2}{3}$ in *Canis* and *Ursus.* In the upper jaw the incisor teeth progressively increase in size, so that there is no such marked contrast between i. 3 and c.

as there is in *Felis* (see Pl. IV, fig. 1). The canines are less powerful than in *Ursus* and *Felis*, and are oval in transverse section, without any longitudinal groove or angle separating the inner third. Pm. 3, pm. 3, and pm. 4, the large and powerful bone-crushing teeth, are very characteristic, as is the form of the carnassial teeth. The features of the teeth will be now more fully described.

(2) *Permanent Dentition of the Upper Jaw* (see Pl. IV).—I. 1 and 2 show a prominent anterior cone or cusp separated by a groove from a depressed posterior area, which is divided by a second groove into right and left cusps. These teeth have wide laterally compressed and somewhat squarely truncated roots.

I. 3 is a much larger caniniform tooth, with a marked ridge specially developed antero-externally where it encroaches on the crown. The root is massive and subcylindrical.

C. The canine has the usual form. Its crown forms about one third of its length, and is not traversed by grooves, as in the Felidæ. It is thickest in the middle, and tapers nearly as rapidly towards the end of the root as towards the tip of the crown. It is not always easy to distinguish between an upper and a lower canine, but Dawkins remarks that the upper differs from the lower by the absence of the lateral curvature of the root.

Pm. 1 is a small one-rooted tooth. Its crown forms a low, somewhat incurved cone traversed by a longitudinal ridge.

Pm. 2 is a stout tooth with a low cone and small accessory cusps placed internally and posteriorly. The base of the crown is surrounded by a well-marked cingulum, and the tooth is fixed in the jaw by a pair of stout, subequal, and only slightly divergent roots.

Pm. 3 is a far larger and stronger tooth than pm. 2. The crown forms a stout, slightly incurved cone. The cingulum is strongly developed, and is much thickened posteriorly and antero-internally, sometimes forming irregular cusps from which marked ridges ascend the cone. The tooth forms a powerful bone-crusher.

Pm. 4 is the upper carnassial, and is larger than any other molar or premolar tooth in either jaw. The long trenchant blade is divisible into three lobes: an anterior one, the smallest of the three, and forming little more than a large cusp; a middle one which rises into a point; and a posterior one which is the longest of the three, and is divided from the middle one only by a deep narrow notch. On the inner side of the first lobe is a large but low inner tubercle. There are three roots, two smaller ones placed side by side anteriorly, and a very large laterally compressed posterior root.

M. 1 is not represented in the British Museum set figured on Pl. IV. Dawkins describes it as follows :[1]—"Very small, equilateral-triangular, and supported by two fangs, of which the anterior and outer is by far the smaller; the posterior supporting the two posterior angles is enclosed in an alveolus with very delicate walls, which would soon disappear by absorption after the loss of the tooth."

(3) *Permanent Dentition of the Lower Jaw* (see Pl. IV).—The three incisors are all

[1] 'Nat. Hist. Rev.,' n. s., v, 1865, p. 90.

teeth of much the same form, progressively increasing in size to a slight extent when followed backwards.

$\overline{\text{I. 1}}$ has a low crown with a simple transversely extended trenchant edge; the root is three times as long as the crown, and is laterally compressed.

$\overline{\text{I. 2}}$ differs from $\overline{\text{i. 1}}$ in being slightly larger and in bearing a small cusp on its outer side.

$\overline{\text{I. 3}}$ is again a good deal larger, and has a more conical, less transversely extended crown. It has a small but well-marked cusp on its outer side, and sometimes a slight indication of a cusp on its inner side, these features being in each case due to the enlargement of the cingulum. The root is much wider anteriorly than posteriorly, so as to be nearly triangular in section.

$\overline{\text{C.}}$ is much like that of the upper jaw, and has the inner side of the crown marked by two slight ascending ridges. The root is slightly more outwardly twisted than is the case with the upper canine, and it frequently, at any rate, tapers rather more rapidly to the point of implantation than is the case with that of the upper canine.

$\overline{\text{Pm. 1}}$ is absent.

$\overline{\text{Pm. 2}}$ is much like $\underline{\text{pm. 2.}}$ The crown forms a broad but low cone springing from a very marked cingulum. A groove separates off a posterior cusp from the main part of the cone, while sometimes a second but less distinct groove marks off an anterior cusp. Of the two roots the posterior is the larger, and the anterior has its tip bent backwards.

$\overline{\text{Pm. 3}}$ is a powerful conical tooth much resembling $\underline{\text{pm. 3.}}$ It has a very stout cone surrounded by a cingulum, least developed on the outer face, and thickened posteriorly into a fairly well-marked cusp. From this cusp, and from a slighter thickening on the anterior face, faint ridges ascend to the top of the cone. The two roots are stout, subcylindrical and subequal, the anterior being slightly the longer.

$\overline{\text{Pm 4}}$ is intermediate in character between $\overline{\text{pm. 2}}$ and $\overline{\text{pm. 3}}$ just described. The crown is traversed by a strong ridge dividing it into subequal right and left halves. At the anterior end is a small cusp; then follows a prominent cone, and lastly a large and somewhat irregular cusp.

$\overline{\text{M. 1}}$, the carnassial tooth of the lower jaw, has a very large trenchant blade divided by a deep groove into two parts, the relative proportion between which is variable, but the anterior is somewhat the larger. The cingulum is well marked, especially on the antero-outer side and posteriorly, where it merges into the much reduced tubercular portion of the tooth to form a small talon or cusp. This cusp is subject to a large amount of variation in different specimens, and upon these variations several supposed species have been based by French palæontologists. The principal variations, which are fully described by Dawkins,[1] are as follow:

1. A ridge passes obliquely across the tubercle towards the posterior part of the

[1] 'Nat. Hist. Rev.,' n. s., v, p. 92.

blade, from which it is separated by a small cleft without any cusp; this is the most common form.

2. A small cusp intervenes between the aforesaid ridge and the blade (characteristic of *H. intermedia,* de Serres, Dubrueil, and Jeanjean).

3. In place of the ridge occurring in 1 is a groove dividing the inner from the outer part of the tubercle, which thus becomes bilobed. The cusp occurring in 2 is not present (*H. Perrieri*, Croizet and Jobert).

Boyd Dawkins states that these are all to be regarded as mere variations of the typical form, and by no means as characters of specific value. In this view he has been followed by most subsequent writers.

(4) *Differences between the Teeth of the Living* Hyæna crocuta *and those of* Hyæna striata *and* Hyæna brunnea.—The many and marked differences between the teeth of *H. crocuta* and those of *H. striata* and *H. brunnea* were long ago described by de Blainville[1] and by Busk,[2] and may be summarised as follows:

1. In *H. striata* and *H. brunnea* the upper molar is triradicular[3] and tricuspid, and rarely measures less than 0·5 by 0·2 inch, being considerably larger than that of *H. crocuta*. In *H. crocuta* it is normally biradicular (occasionally monoradicular) and bicuspid, and is often absent (as in five skulls examined at the British Museum).

2. In *H. striata* and *H. brunnea* the three lobes of the upper carnassial $\underline{\text{(pm. 4)}}$ are subequal antero-posteriorly, while in *H. crocuta* the last lobe is more than twice as long as the first. This fact was noted by Cuvier.[4]

3. In *H. striata* and *H. brunnea* there is a more or less distinct accessory point on the inner side of the posterior cusp of the lower carnassial $\overline{\text{(m. 1)}}$, which is absent or less developed in *H. crocuta*. Cuvier noted the occurrence of this accessory point, and says it disappears with age. The lower carnassial is relatively much smaller in *H. striata* than in *H. crocuta,* whose lower carnassial approaches somewhat closely to that of the Felidæ.

4. The second upper premolar is relatively smaller and the third larger than in *H. striata,* so that the contrast between the second and third is much greater in *H. crocuta* than in *H. striata*. Busk stated that the third upper premolar is also somewhat obliquely truncated behind in *H. striata,* while in *H. crocuta* it is square behind. This, however, is not particularly apparent in the British Museum skulls. In *H. striata* the second lower premolar has an anterior accessory cusp better developed than in *H. crocuta*.

5. The first, second, and third upper premolars in *H. striata* have the anterior cusp better developed than in *H. crocuta*.

[1] 'Ostéographie, Hyènes,' p. 21. [2] 'Trans. Zool. Soc.,' x (2), p. 77.

[3] According to de Blainville, as noted by Dawkins ('Nat. Hist. Rev.,' n. s., v, p. 81), the molar is monoradicular.

[4] 'Oss. Foss.,' ed. 3, iii (1825), p. 399.

6. In *H. striata* and *H. brunnea* the second and third premolars, both upper and lower, are placed with the long axes oblique to the line of the alveolar border, while in *H. crocuta* this is not so.

(5) Table of Measurements of the Permanent Teeth.

Hyæna spelæa = crocuta, Tor Bryan caves, Torquay (Brit. Mus.), fig. Pl. IV. m. 1 is from Wookey Hole.	i. 1.	i. 2.	i. 3.	c.	pm. 1.	pm. 2.	pm. 3.	pm. 4.	m. 1.	i. 1.	i. 2.	i. 3.	c.	pm. 2.	pm. 3.	pm. 4.	m. 1.
1. Antero-posterior extent at base of crown.....	0·8	1·0	1·3	1·75	0·75	1·85	2·5	4·5	0·5	0·55	0·6	0·9	1·05	1·7	2·2	2·25	3·35
2. Maximum transverse measurement	0·65	0·7	1·0	1·35	0·7	1·4	1·7	2·1	0·5	0·4	0·55	0·8	1·35	1·3	1·55	1·35	1·4
3. Maximum length	2·4	2·7	4·15	6·3	2·05	2·95	4·6	4·55	...	2·3	2·55	3·6	6·2	2·75	4·5	3·95	4·0
4. Measurements taken from notch between roots to top of crown	...	...	...	...	...	1·2	2·7	2·4	...	..	...	...	...	1·05	2·15	1·9	...

(6) *Succession of Teeth in Hyæna.*—This subject has been dealt with by Boyd Dawkins,[1] who mentions that in the upper jaw the first tooth to appear is pm. 1. In the lower jaw, to judge by two specimens in the British Museum, c. and i. 1 appear first, followed by the large carnassial tooth m. 1, and by pm. 2; the other premolars, pm. 3 and 4, appearing somewhat later.

Boyd Dawkins mentions that the first teeth to disappear in the adult hyæna are the large bone-crushers pm. 2 and 3, and pm. 3 and 4; these teeth are always very much worn in the middle-aged adult, while pm. 1 and pm. 2 show scarcely any trace of wear.

(7) *Distinctive Features of the Deciduous Dentition of the Genus Hyæna.*—The formula for the deciduous dentition in *Hyæna* is d.i. $\frac{3}{3}$ d.c. $\frac{1}{1}$ d.m. $\frac{4}{3}$, as in *Canis* and *Ursus*, as compared with d.i. $\frac{3}{3}$ d.c. $\frac{1}{1}$ d.m. $\frac{3}{2}$ in *Felis*.

I have not had an opportunity of examining the deciduous incisors, but de Blainville notes that they differ from those of the adult in having the crown quite undivided. There is no noteworthy difference in the canines. The most distinctive teeth are the deciduous carnassials d.m. 3 and d.m. 4.

D.m. 1. The only example of this tooth that I have seen is that shown in Pl. V, fig. 5. The fragment of the upper jaw showing deciduous dentition figured in Pl. V, figs. 3, 4, bears no trace of its alveolus. Dawkins[2] describes it as follows:—"Trenchant, conical, and slightly incurved. Its anterior base, narrower than the posterior, bears a small cusp, while the posterior generally exhibits a slight thickening without the cusp. Sometimes,

[1] 'Nat. Hist. Rev.,' n. s., v.

[2] Ibid., v, p. 86.

however, the accessory cusp is developed behind and suppressed before. The crown is supported by two fangs, cylindrical and divaricant, the posterior being by far the stouter."

D.m. 2 is a simple conical tooth with no marked accessory cusps. The base is slightly wider posteriorly than anteriorly. There are two strong roots, the posterior being the larger. They do not diverge so much as do those of d.m. 1.

D.m. 3, the milk carnassial, has much the same general form as the permanent carnassial, and consists of a long sectorial portion and an inner tubercle. The sectorial portion shows two small cusps placed anteriorly and obliquely, and two large subequal blades separated from one another by a deep and narrow notch. The inner tubercle which arises from the anterior half of the blade is low, but extends a long way inwards. There are three roots, a small one supporting the inner tubercle, and two large divergent ones supporting the main part of the tooth.

D.m. 4, as noted by Dawkins, is remarkable for its size, and its resemblance to m. 1 in *Hyæna striata*. Its crown is shaped like an iscsceles triangle with a broad forwardly directed base. The three angles are connected by a stout ridge, and each is supported by a divergent root.

D.m. 2 is a simple conical tooth with two marked accessory cusps, though occasionally small cusps may be developed at either end of the tooth. The base of the crown is wider posteriorly than anteriorly, and of the two roots, which diverge strongly, the posterior is the thicker.

D.m. 3 consists of a well-marked median cone and two small cusps, one placed antero-internally, the other posteriorly. On the inner side of the posterior cusp is a small accessory ridge. There are two divergent cylindrical subequal roots.

D.m. 4 is the carnassial tooth. Its cutting edge is divided into two subequal blades separated from one another by a cleft. Separated from the posterior blade by a well-marked groove is a large tubercle which usually shows indistinct division into three little cusps. Boyd Dawkins notes that occasionally all three cusps are suppressed, and the ridge which takes their place is cleft posteriorly, giving the tubercular portion a slightly bilobed appearance.

(8) Measurements of the Deciduous Teeth.

Upper.

	Teeth in fragment of jaw from Creswell Cave, figured in Pl. V, figs. 3 and 4.			Teeth in fragment of jaw from Brixham (Brit. Mus.).		
	d.m. 2.	d.m. 3.	d.m. 4.	d.m. 2.	d.m. 3.	d.m. 4.
Maximum antero-posterior measurement ...	1·5	2·2	0·8	1·15	2·2	0·8
Maximum transverse measurement of crown	0·6	0·75	1·4	0·7	0·8	1·35
Measurement from notch between roots to top of crown	0·75	0·9	...	...	...	...

(8) MEASUREMENTS OF THE DECIDUOUS TEETH (*continued*).

	Lower.					
	Teeth in jaw from Kent's Hole, Torquay, figured in Pl. III, fig. 4 (Brit. Mus. No. 1743).			Teeth in jaw from Kirkdale Cave (Brit. Mus. No. 36).		
	d.m. 2.	d.m. 3.	d.m. 4.	d.m. 2.	d.m. 3.	d.m. 4.
Maximum antero-posterior measurement ...	1·05	1·45	2·1	1·05	1·5	2·05
Maximum transverse measurement of crown	0·65	0·75	0·7	0·55	0·7	0·65
Measurement from notch between roots to top of crown	0·65	0·8	...	...	...	...

C. THE VERTEBRAL COLUMN (Pls. VI, VII, VIII).

(1) *Distinctive Features of the Vertebral Column of the Genus Hyæna.*—There are not many distinguishing features characterising the vertebral column in *Hyæna* as compared with that in other Carnivora. Twenty is the regular number of thoraco-lumbar vertebræ in the great majority of Carnivora, but the relative proportion of thoracic to lumbar varies from thirteen thoracic and seven lumbar in *Felis, Canis,* and *Viverra,* to sixteen thoracic and four lumbar in *Arctonyx collaris.* In *Hyæna* there are fifteen thoracic to five lumbar vertebræ.

The small size of the thoracic vertebral centra, and the rapid decrease in the length of the neural spines when followed back, are features characterising *Hyæna.* The first sacral vertebra is a good deal larger than the others, causing the sides of the pelvis to converge posteriorly as in *Ursus,* instead of being approximately parallel as in *Canis.*

(2) *Distinctive Features of the Vertebral Column in the Different Species of Living Hyæna.*—There seems to be no marked difference between the vertebral columns of *H. crocuta* and *H. striata,* except that in *H. crocuta* the sacrum includes four vertebræ, while in *H. striata* there are three. There are only eighteen caudal vertebræ in *H. crocuta,* as compared with twenty-three in *H. striata.* Most of the vertebræ are more massive in *H. crocuta* than in *H. striata,* and the size of the vertebræ when followed back decreases somewhat more rapidly in the former than in the latter species.

(3) Tables of Comparative Measurements of Hyæna Vertebræ.

	H. crocuta, No. 522 (College of Surgeons).	*H. spelæa* = *crocuta*, Wookey (Taunton Museum), skeleton A.	*H. spelæa* = *crocuta*, Wookey (Taunton Museum), skeleton B.
Atlas.			
Maximum width	12·9	15·1	14·6
Median dorso-ventral diameter	3·9	4·1	3·9
Extreme width of the condylar articular surfaces	...	6·3	6·15
Maximum width of neural canal	2·6	2·8	2·55
Axis.			
Length from anterior end of odontoid process to postero-ventral extremity of centrum	7·0	7·3[1]	...
Height from roof of neural canal to top of neural spine	3·4	3·7	3·55
Transverse diameter across prezygapophyses	4·9	5·2	4·8
Transverse diameter across postzygapophyses.............	5·15	5·35	5·5
Length from anterior end of neural spine to notch between postzygapophyses	5·7	7·3	6·35

[1] Figured.

	3rd cervical.			4th cervical.			5th cervical.		
	H. crocuta, No. 522 (College of Surgeons).	*H. spelæa* = *crocuta*, Wookey (Taunton Museum), A.	*H. spelæa* = *crocuta*, Wookey (Taunton Museum), B.	*H. crocuta*, No. 522 (College of Surgeons).	*H. spelæa* = *crocuta*, Wookey (Taunton Museum), A.	*H. spelæa* = *crocuta*, Wookey (Taunton Museum), B.	*H. crocuta*, No. 522 (College of Surgeons).	*H. spelæa* = *crocuta*, Wookey (Taunton Museum), A.	*H. spelæa* = *crocuta*, Wookey (Taunton Museum), B.
Maximum length of centrum taken from the dorso-anterior to the ventro-posterior edge	4·8	4·65[1]	5·0	4·95	5·0	5·1	4·9	5·1	4·95
Length from antero-dorsal to postero-dorsal extremity of the centrum	3·2	3·35	3·35	3·55	3·6	3·65	3·5	3·3	3·0
Width across transverse processes	7·5	8·1	7·2	8·65	7·8	7·4	7·45	7·9	7·7
Width across postzygapophyses	5·8	6·8	6·0	5·6	6·85	5·95	5·65	6·75	6·1
Height from roof of neural canal to top of neural spine	2·1	...	2·6	1·95	...	2·6	2·55	2·15	2·4

[1] Figured.

Note.—The letter A or B appearing after a bone indicates that it forms part of skeleton A or skeleton B described on p. 6.

COMPARATIVE MEASUREMENTS OF HYÆNA VERTEBRÆ (*continued*).

	6th cervical.			7th cervical.		
	H. crocuta, No. 522 (College of Surgeons).	*H. spelæa* = *crocuta*, Wookey (Taunton Museum), A.	*H. spelæa* = *crocuta*, Wookey (Taunton Museum), B.	*H. crocuta*, No. 522 (College of Surgeons).	*H. spelæa* = *crocuta*, Wookey (Taunton Museum), A.	*H. spelæa* = *crocuta*, Wookey (Taunton Museum), B.
Maximum length of centrum from dorso-anterior to ventro-posterior edge	4·9	5·0[1]	4·8	...	4·1[1]	...
Length from dorso-anterior to dorso-posterior edge of centrum	...	3·2	3·25	...	2·85	...
Width across transverse processes	6·35	7·45	7·4	8·2	7·6	8·0
Width across postzygapophyses	...	6·8	5·9	5·3	5·9	5·6
Height from roof of neural canal to top of neural spine	2·15	3·2	...	...	3·2	...
Length of inferior lamella of transverse process	4·25	5·25	...	...	...	...

[1] Figured.

	1st thoracic.			2nd thoracic.		3rd thoracic.			4th thoracic.		
	H. crocuta, No. 522 (College of Surgeons).	*H. spelæa* = *crocuta*, Wookey (Taunton Museum), A.	*H. spelæa* = *crocuta*, Wookey (Taunton Museum), B.	*H. crocuta*, No. 522 (College of Surgeons).	*H. spelæa* = *crocuta*, Wookey (Taunton Museum), A.	*H. crocuta*, No. 522 (College of Surgeons).	*H. spelæa* = *crocuta*, Wookey (Taunton Museum), A.	*H. spelæa* = *crocuta*, Wookey (Taunton Museum), B.	*H. crocuta*, No. 522 (College of Surgeons).	*H. spelæa* = *crocuta*, Wookey (Taunton Museum), A.	*H. spelæa* = *crocuta*, Wookey (Taunton Museum), B.
Length from dorso-anterior to dorso-posterior edge of centrum	...	3·0	2·9	2·55	2·7	...	2·5	2·55	...	...	2·35
Width across prezygapophyses	...	5·9	5·9	4·15	4·1	...	3·35	3·3	...	3·4	2·8
Width across postzygapophyses	4·35	4·3	4·5	3·4	3·4	...	3·35	2·9	...	3·0	2·6
Width across transverse processes	7·6	7·8	7·9	7·95	6·85	6·6	6·8	6·75	6·2	6·5	6·5
Length of neural spine from notch between prezygapophyses	...	...	...	...	8·0	...	9·75	...	...	8·95	7·75

COMPARATIVE MEASUREMENTS OF HYÆNA VERTEBRÆ (*continued*).

	5th thoracic.			6th thoracic.			7th thoracic.			8th thoracic.			9th thoracic.		
	H. crocuta, No. 522 (College of Surgeons).	*H. spelæa* = *crocuta*, Wookey (Taunton Museum).	*H. spelæa* = *crocuta*, Wookey (Taunton Museum), B.	*H. crocuta*, No. 522 (College of Surgeons).	*H. spelæa* = *crocuta*, Wookey (Taunton Museum), A.	*H. spelæa* = *crocuta*, Wookey (Taunton Museum), B.	*H. crocuta*, No. 522 (College of Surgeons).	*H. spelæa* = *crocuta*, Wookey (Taunton Museum), A.	*H. spelæa* = *crocuta*, Wookey (Taunton Museum), B.	*H. crocuta*, No. 522 (College of Surgeons).	*H. spelæa* = *crocuta*, Wookey (Taunton Museum), A.	*H. spelæa* = *crocuta*, Wookey (Taunton Museum), B.	*H. crocuta*, No. 522 (College of Surgeons).	*H. spelæa* = *crocuta*, Wookey (Taunton Museum), A.	*H. spelæa* = *crocuta*, Wookey (Taunton Museum), B.
Maximum length of centrum	...	2·65	2·6	...	2·45	...	...	2·5	2·5	...	2·5	2·7	...	2·65	2·6
Width across transverse processes	6·1	6·5	6·45	5·8	5·85	...	5·85	5·55	6·05	5·7	4·8	5·4	5·55	5·25	5·45
Length of neural spine from notch between prezygapophyses ...	...	7·75	8·7	...	7·85	...	...	7·5	...	...	6·8	7·15	...	5·95	6·35

	10th thoracic.			11th thoracic.			12th thoracic.			13th thoracic.			14th thoracic.		
Maximum length of centrum	...	2·6	2·6	...	2·65	2·65	...	2·8	2·7	...	2·7	2·8 [1]	...	3·0	2·95
Width across transverse processes	5·5	...	5·25	5·55	5·0	4·8	...	4·7	4·45	...	4·45	4·25	...	4·2	4·2
Length of neural spine from notch between prezygapophyses ...	...	...	5·45	...	...	4·95	...	...	...	...	4·1	4·15	...	...	...

	1st lumbar.		2nd lumbar.		3rd lumbar.			4th lumbar.		5th lumbar.			
	H. crocuta, No. 522 (College of Surgeons).	*H. spelæa* = *crocuta*, Wookey (Taunton Museum), A.	*H. crocuta*, No. 522 (College of Surgeons).	*H. spelæa* = *crocuta* Wookey (Taunton Museum), A.	*H. crocuta*, No. 522 (College of Surgeons).	*H. spelæa* = *crocuta* Wookey (Taunton Museum), A.	*H. spelæa* = *crocuta*, Wookey (Taunton Museum), B.	*H. crocuta*, No. 522 (College of Surgeons).	*H. spelæa* = *crocuta*, Wookey (Taunton Museum), A.	*H. crocuta*, No. 522 (College of Surgeons).	*H. spelæa* = *crocuta*, Wookey (Taunton Museum), A.	*H. spelæa* = *crocuta*, Wookey (Taunton Museum).	*H. spelæa* = *crocuta* Wookey (Taunton Museum), B.
Maximum length of centrum	2·85	3·05	2·75	3·1	2·9	3·35	3·45	2·95	3·4 [1]	...	2·8	3·1 [1]	3·15 [1]
Width across processes bearing prezygapophyses	4·6	4·2	4·5	4·15	4·15	4·10	4·3	...	3·75	...	3·6	...	3·5
Height of neural spine measured from roof of neural canal	...	4·15	...	4·4	...	...	...	4·15	3·9	...	3·6	...	2·75
Diameter across transverse processes	...	...	...	9·0	...	..	...	...	12·1	10·6	...	9·7	...

SACRAL.

Maximum transverse diameter of 1st (true sacral) vertebra	7·95	8·9	8·8
Height of centrum ..	...	1·9	1·9
Height of neural canal	...	0·7	0·8

[1] Figured.

D. The Ribs and Sternum.

Hyæna possesses fifteen pairs of ribs, which are much arched, causing the cavity of the chest to be large as compared with that in *Canis*, and very large as compared with that in *Felis*. The sternum includes eight sternebræ. Neither ribs nor sternum present any features of special importance.

E. The Shoulder Girdle (Pl. IX).

The scapula in *H. crocuta* is straighter, and the postscapular fossa relatively smaller than in *H. striata*. The coracoid process is very little marked in *Hyæna*, and the clavicle, which is minute and more or less oval in outline, is entirely suspended in the muscles.

Table of Measurements of the Scapula.

	H. crocuta, No. 522 (College of Surgeons).	*H. spelæa* = *crocuta*, Creswell (Owens College Museum).	*H. spelæa* = *crocuta*, Wookey (Taunton Museum), A.
Length along line of spine	17·8	19·55 [1]	20·95
Antero-posterior diameter of neck	4·2	5·25	4·6
Maximum length of glenoid cavity	4·45	4·5	4·5
Diameter from highest point in spine to point on inner surface of scapula immediately below	4·95	4·25	4·0
Length from end of coracoid process to surface of bone behind glenoid cavity	...	6·0	6·0

[1] Figured.

F. The Anterior Limb (Pls. X, XI).

The humerus of *Hyæna* is a well-marked bone. Its form is short and robust, with an exceptionally large great tuberosity. The condyle is larger and more pronounced than in *Canis*, the radial part being specially large. The deltoid crest extends further down the shaft in *H. crocuta* than in *H. striata*. The humerus differs from that of *Canis*, *Ursus*, and *Mustela* in nearly always having a supra-trochlear foramen. There is no entepicondylar foramen such as occurs in *Canis* and *Mustela*, and neither an ectepicondylar foramen nor crest occurs.

The manus of *Hyæna* differs from that of all other Carnivora in having the pollex represented by only a rudimentary metacarpal, which resembles a sesamoid bone. The metacarpals are longer and less enlarged above the phalangeal articulation than in *Felis*.

TABLES OF COMPARATIVE MEASUREMENTS.

	H. crocuta, No. 522 (College of Surgeons).	*H. spelæa = crocuta*, Wookey (Taunton Museum), A.	*H. spelæa = crocuta*, Wookey (Taunton Museum), B.	*H. spelæa = crocuta*, Creswell (Owens College Museum).
HUMERUS (right).				
Extreme length	21·6	22·3	23·8 [1]	...
Diameter of proximal end passing across centre of articulating surface and greater tuberosity	6·4	...	6·7	...
Vertical diameter of shaft at middle of deltoid ridge	3·2	3·8	4·3	...
Transverse diameter at same point	2·2	2·2	2·4	...
Maximum transverse diameter at distal end	5·65	5·9	5·85	5·6
Maximum width of trochlea	4·65	4·7	4·55	4·4

[1] Figured.

	H. crocuta, No. 522 (College of Surgeons).	*H. spelæa = crocuta*, Wookey (Taunton Museum), A.	*H. spelæa = crocuta*, Wookey (Taunton Museum), B.	*H. spelæa = crocuta*, Creswell (Owens College Museum).
RADIUS (right).				
Extreme length	21·65	21·9	21·9 [1]	...
Right and left or transverse measurement at humeral articulation	3·1	3·0	3·3	3·0
Antero-posterior or vertical measurement at humeral articulation	...	2·05	2·25	2·1
Transverse diameter at carpal articulation	4·1	3·95	4·55	...
Vertical diameter at carpal articulation	2·7	2·5	2·65	...
Transverse diameter at middle of shaft	2·65	2·25	2·65	2·35
Vertical diameter at middle of shaft	1·2	1·4	1·6	1·6
ULNA (right).				
Extreme length	24·15	25·65	25·3	..
Maximum vertical measurement	4·7	4·6	5·1	4·3
Maximum transverse measurement of olecranon	2·55	2·15	2·95	...
Transverse diameter at carpal articulation	1·15	1·1	1·2	...
Vertical diameter at carpal articulation	1·8	1·8	1·6	...

[1] Figured.

TABLE OF COMPARATIVE MEASUREMENTS (*continued*).

	H. crocuta, No. 522 (College of Surgeons).	*H. spelæa = crocuta*, Tor Bryan, Torquay (Brit. Mus.).	*H. spelæa = crocuta*, Wookey (Taunton Museum).
Length of first metacarpal	2·35	3·35 [1]	...
" second metacarpal	7·5	7·6	7·7
" third metacarpal	9·2	8·15	8·95
" fourth metacarpal	9·0	8·6	8·75
" fifth metacarpal	7·6	7·45	7·1

[1] Figured.

The above measurements tend to confirm Cuvier's observation that the metacarpals of the cave hyæna are relatively shorter than those of the living spotted hyæna.

G. THE PELVIC GIRDLE (Pl. XII).

The pelvis of *Hyæna* is characterised by its shortness, its comparatively large size, and its obliquity with regard to the sacrum. The ilium is decidedly larger in proportion to the size of the animal than in bears, and is prolonged into an anterior downwardly directed hook.

TABLES OF MEASUREMENTS.

	H. crocuta, No. 522 (College of Surgeons).	*H. spelæa = crocuta*, Wookey (Taunton Museum), A.
RIGHT INNOMINATE BONE.		
Maximum length	19·55	22·5 [1]
Length from acetabulum to border of ilium	11·1	12·6
Vertical measurement of ilium	10·55	10·9
Thickness of ilium at middle of surface	0·95	0·95
Antero-posterior diameter of acetabulum	3·25	3·55
Length from acetabulum to posterior border of ischium	4·85	6·5
LEFT INNOMINATE BONE.		
Maximum diameter of obturator foramen	4·1	5·15 [1]
Measurement along ischium from symphysis to end of ischial spine	7·5	...

[1] Figured.

H. THE POSTERIOR LIMB (Pls. XIII, XIV).

The intercondylar notch of the femur is less deep than in *Canis*. The cnemial crest of the tibia gradually dies away instead of being strongly truncated as in *Canis*. The hallux in *Hyæna*, as in *Canis* and *Felis*, is represented only by a vestigial metatarsal.

TABLES OF MEASUREMENTS.

	H. crocuta, No. 522 (College of Surgeons).	*H. spelæa = crocuta*, Wookey (Taunton Museum), A.	*H. spelæa = crocuta*, Wookey (Taunton Museum), B.
RIGHT FEMUR.			
Maximum length	23·7	25·7 [1]	26·0
Transverse diameter at condyles	5·1	5·5	5·3
Antero-posterior diameter of head	3·25	3·15	3·15
Vertical or antero-posterior diameter of shaft at middle	1·8	1·9	1·9
Transverse or right to left diameter of shaft at middle	2·5	2·35	2·35
Transverse diameter at proximal end measured across head and great trochanter	6·35	6·9	6·55
RIGHT TIBIA.			
Maximum length	18·9	20·1	19·9 [1]
Transverse or right to left diameter at proximal end	5·3	5·3	5·5
Vertical or antero-posterior diameter at proximal end measured from notch between articulating surface for femur and top of crest	5·25	5·4	5·25
Transverse diameter at distal end	4·05	3·9	4·2
Vertical diameter at distal end	2·45	2·6	2·85
Transverse diameter at narrowest part of shaft	1·75	1·8	2·15

[1] Figured.

	H. crocuta, No. 522 (College of Surgeons).	*H. spelæa = crocuta*, Wookey (Taunton Museum), B.	*H. spelæa = crocuta*, Tor Bryan, Torquay (Brit. Mus.).
RIGHT FIBULA.			
Maximum length	17·8	17·85	...
Transverse diameter at distal end	1·25	1·25	...
Vertical diameter at distal end	2·10	2·15	...
Transverse diameter at proximal end	1·0	0·9	...
Vertical diameter at proximal end	1·4	1·4	...
CALCANEUM.			
Length	5·9	...	6·7
Maximum transverse diameter	2·8	...	2·8
ASTRAGALUS.			
Right to left diameter	3·15	...	3·7
METATARSALS.			
Length of first metatarsal	1·75	...	...
,, second metatarsal	7·35	...	7·8
,, third metatarsal	8·4	...	8·0
,, fourth metatarsal	8·2	...	7·95
,, fifth metatarsal	7·2	...	6·75

IV. CONCLUSIONS.

The evidence for the view that the *Hyæna* from the caves is a species distinct from the modern *H. crocuta* may now be more fully considered.

Cuvier,[1] writing in 1825, mentions the following features as characteristic of *H. spelæa*:

1. The upper surface of the skull is less arched than in *H. crocuta*, and the temporal ridges do not unite so quickly to form a sagittal crest.

2. All the bones of the metacarpals and metatarsals measured are without exception shorter and thicker than in *H. crocuta*.

Reference is also made to the relatively thick character of the bones in the cave hyæna by Gaudry,[2] who concludes that the animal was more thick-set than its living representative, and suggests that it may have had a more crouching gait.

Cuvier remarks, however, with regard to the teeth, that it is impossible to distinguish those of *H. spelæa* from those of *H. crocuta*.

De Blainville[3] gives the following features as characteristic of *H. spelæa*:

1. The form of the upper carnassial with the large size of the third lobe (talon).[4]
2. The absence of the inner cusp on the tubercular portion of the lower carnassial.
3. The size, which is $\frac{1}{5}$ larger than in *H. crocuta*.
4. The greater extension and compression of the occipital crest.
5. The increased thickness and shortness of the muzzle.
6. The increased thickness and shortness of the limb bones.

He remarks that of these characters the least important is the increased relative size, and the most important the increased thickness of the limbs and elevation of the occipital crest. Relative size depends on conditions of life, and comparisons as regards size have too often been made between fossil individuals at the maximum of their development, owing to savage life, and individuals raised in menageries. The character of the occipital crest also differs much, according to the age of the animal.

Owen[5] states that the upper true molar in *H. spelæa* is monoradicular, and quotes this as a character distinguishing *H. spelæa* from *H. crocuta*. Dawkins,[6] on the other hand, shows that the tooth in question is sometimes mono-, sometimes bi-radicular, and that the method of implantation cannot be quoted as a character of specific value.

The modern view that there is no specific distinction between *H. spelæa* and *H. crocuta* was first clearly stated by Boyd Dawkins in 1865,[6] and is now almost universally accepted.

1 'Oss. Foss.,' ed. 3, iv, p. 396.

2 'Matér. Hist. Temps Quat.' (4), 1892, p. 118.

3 'Ostéographie, Hyènes,' p. 39.

4 I cannot trace any difference as regards the form of the upper carnassial or the size of the third lobe between *H. spelæa* and *H. crocuta*.

5 'Brit. Foss. Mamm.,' p. 150.

6 'Nat. Hist. Rev.,' n. s., v.

The measurements quoted above, however, show that some of the skulls of the cave hyæna, especially those from the German caves, are considerably larger than those of any modern hyæna measured. They also show that it is true that the metacarpals of the cave hyæna tend to be shorter than those of the modern form, hence it seems reasonable to follow Gaudry[1] in regarding the cave hyæna as a distinct race of *H. crocuta*.

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[1] 'Matér. Hist. Temps Quat.' (4), p. 122.

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PLATE I.

CAVE HYÆNA.

Cranium.

(Two thirds natural size.)

FIG.

1. Palatal view } Skull A from Wookey Hole, now in the Taunton Museum.
2. Dorsal view }

a. Supra-occipital.

b. Occipital condyle.

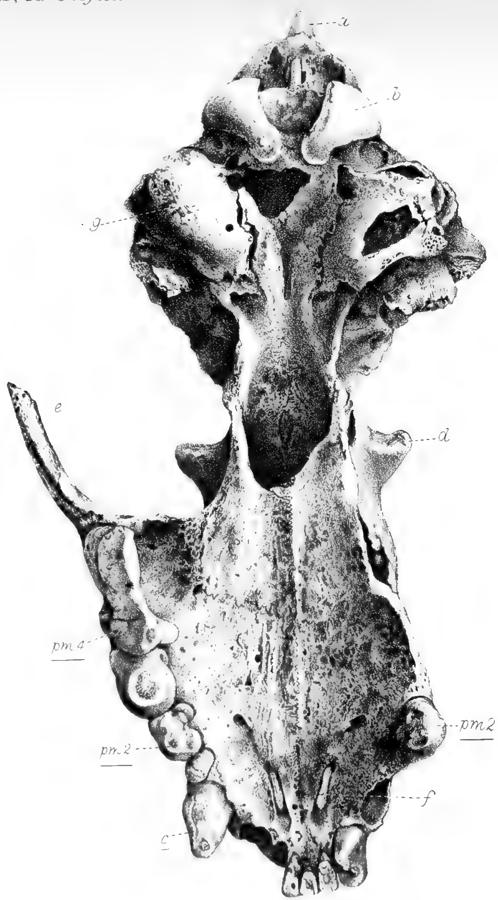
d. Post-orbital process of frontal.

e. Jugal.

f. Anterior palatine foramen.

g. Auditory bulla.

1.



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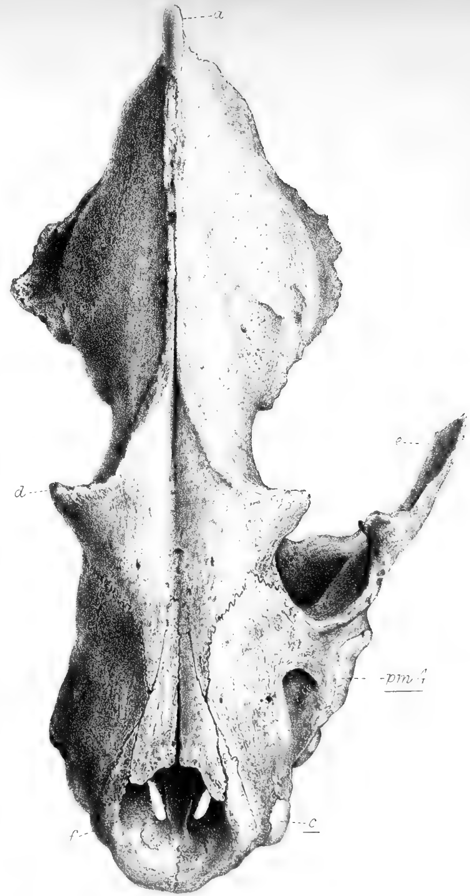


Cranium

... del et lith. Mintern Bros imp.

PLATE II.

Cave Hyæna.

Cranium and Mandible.

(Two thirds natural size.)

Fig.

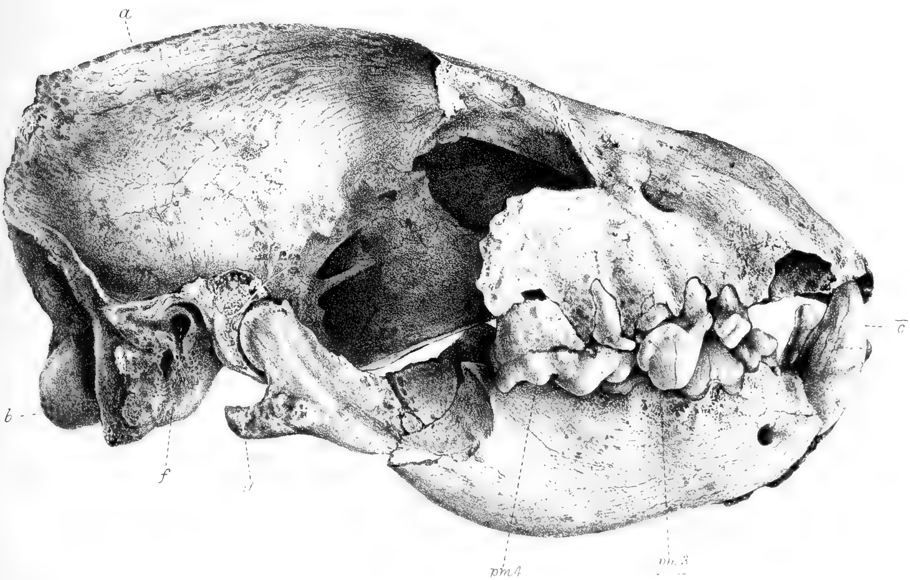
1. Cranium A seen from the left side.
2. Cranium and mandible B seen from the right side.

a. Sagittal crest.
b. Occipital condyle.
d. Post-orbital process of frontal.
e. Jugal.
f. External auditory meatus.
g. Angle of mandible.

Both the above specimens are from Wookey Hole, and are now preserved in the Taunton Museum.

1.

2.



J. Green del. et lith.

Mintern Bros imp.

Cranium & mandible.

PLATE III.

Cave Hyæna.

Cranium and Mandible.

(Two thirds natural size.)

Fig.

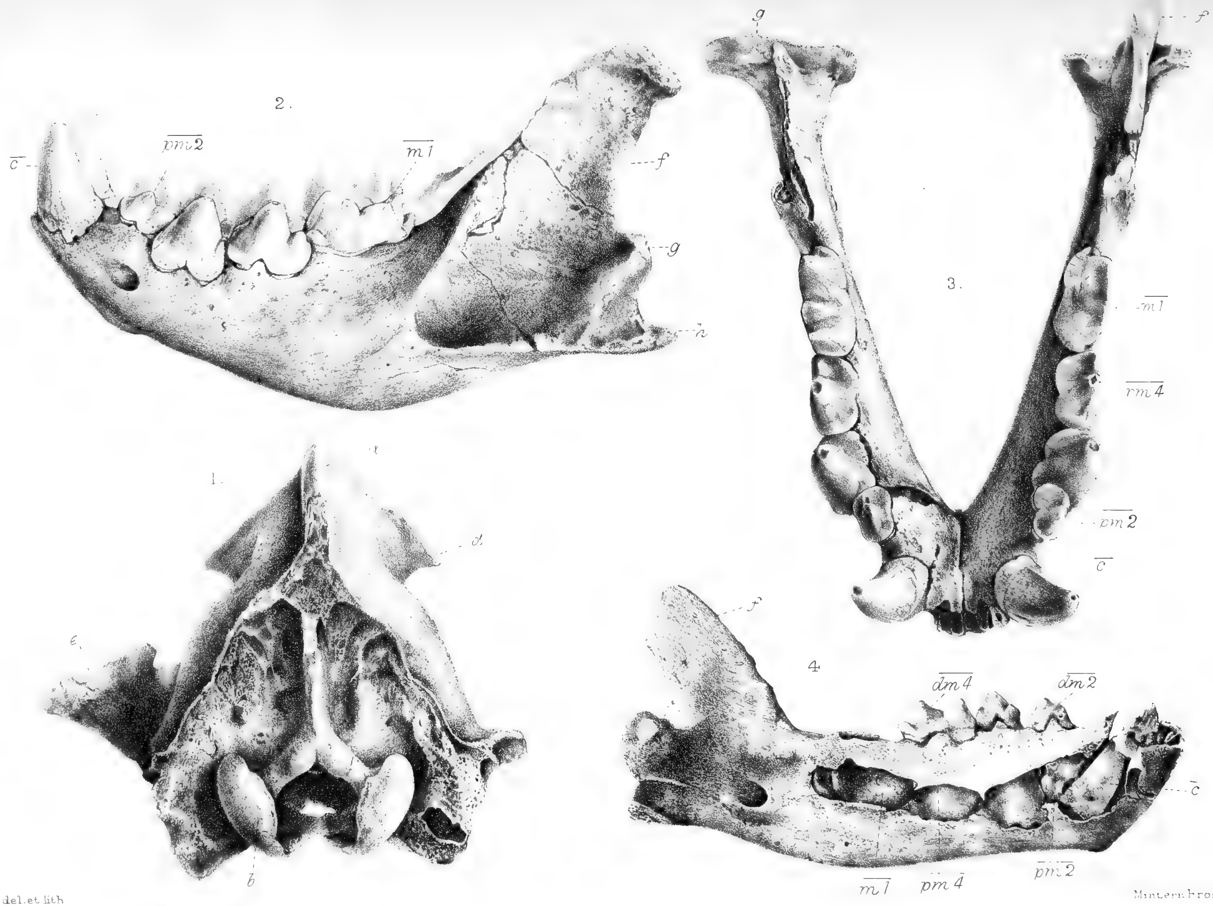
1. Posterior view of Cranium A (Skeleton A).
2. Mandible seen from the left side (Skeleton B).
3. Palatal view of the same mandible (Skeleton B).
4. Inner view of the left mandibular ramus of a young individual showing the milk dentition.

a. Sagittal crest.
b. Post-orbital process of frontal.
d. Jugal.
e. Occipital condyle.
f. Coronoid process.
g. Condyle of mandible.
h. Angle of mandible.

The specimen shown in fig. 4 is from Kent's Hole, Torquay, and is now preserved in the British Museum (Nat. Hist.) at South Kensington. The other specimens are from Wookey Hole, and are now in the Taunton Museum.

Reynolds, Cave Hyæna.

Pl. III.



J Green. del. et lith

Minter Bros. imp.

Cranium & mandible

PLATE IV.

CAVE HYÆNA.

Permanent Dentition.

(Natural size.)

FIG.

1. Right upper teeth, seen from the inner side.
2. Right lower teeth, seen from the inner side.
3. Left upper premolars, seen from the outer side.
4. Left lower premolars and molar, seen from the outer side.

a. Cone of $\underline{\text{i. 2}}$.

b. Anterior cusp of $\underline{\text{pm. 2}}$.

c. Posterior cusp of $\underline{\text{pm. 2}}$.

d. Cone of $\underline{\text{pm. 3}}$.

f. Anterior lobe of blade of $\underline{\text{pm. 4}}$.

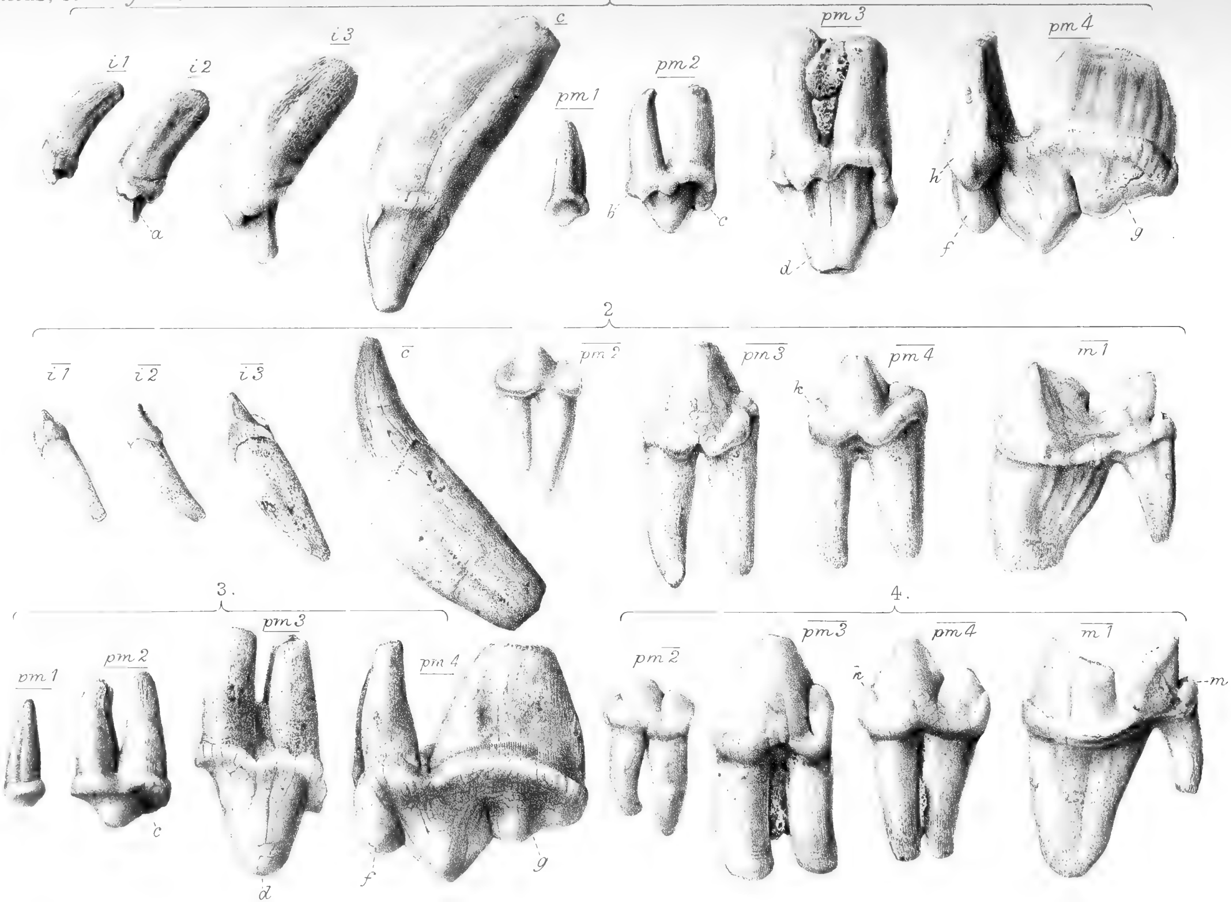
g. Posterior lobe of blade of $\underline{\text{pm. 4}}$.

h. Inner tubercle of $\underline{\text{pm. 4}}$.

k. Anterior cusp of $\overline{\text{pm. 4}}$.

m. Posterior cusp of $\overline{\text{m. 1}}$.

The above specimens are from the Tor Bryan caves, near Torquay, and are now preserved in the British Museum (Nat. Hist.).



J. Green del et lith.

Permanent dentition.

Mintern Bros imp.

PLATE V.

Cave Hyæna.

Dentition.

(Natural size.)

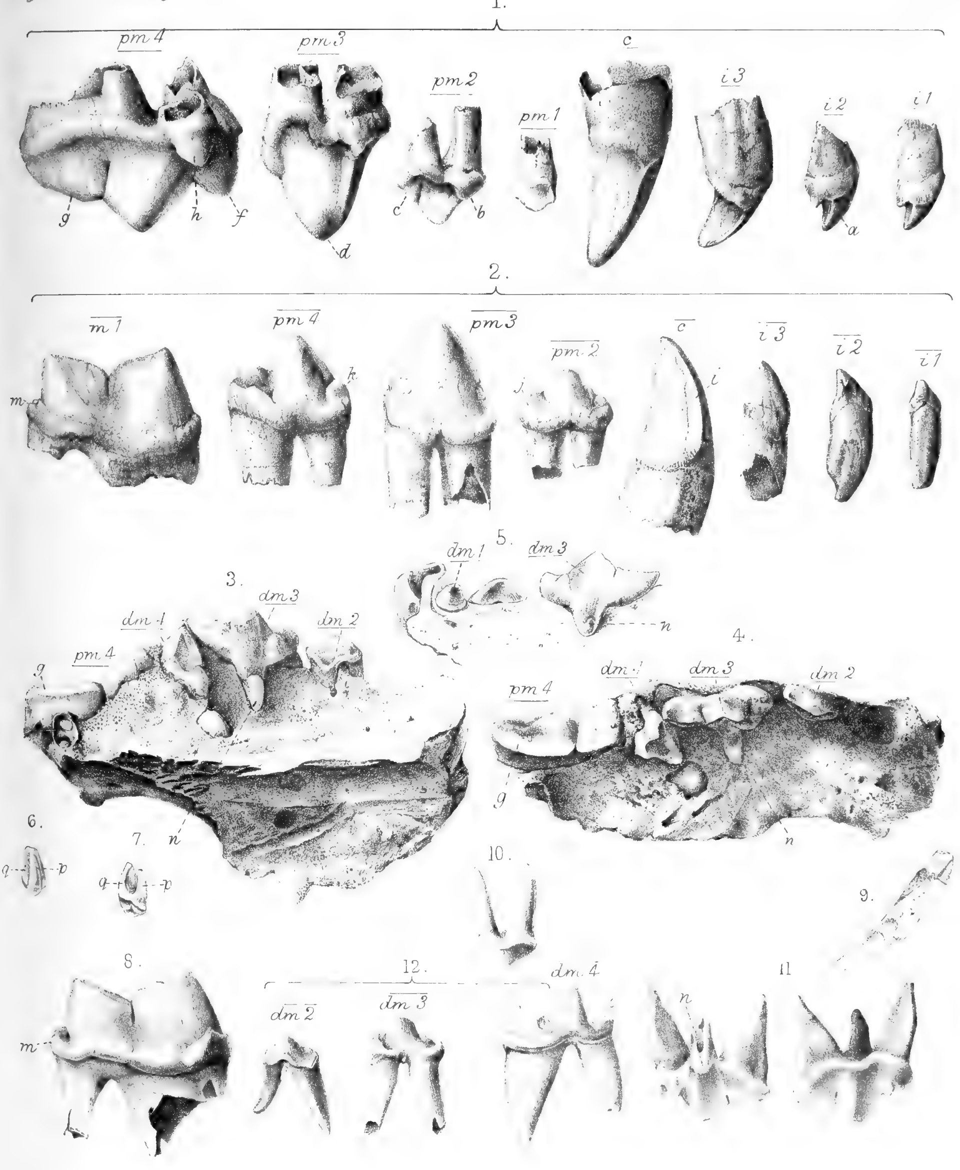
Fig.

1. Left upper permanent teeth which had not yet cut the jaw, seen from the inner side.
2. Left lower permanent teeth which had not yet cut the jaw, seen from the inner side.
3. Inner aspect of fragment of right half of upper jaw showing deciduous dentition.
4. Palatal aspect of the same fragment.
5. Inner aspect of part of left half of upper jaw.
6. Anterior view of $\underline{\text{m. 1}}$.
7. Inner aspect of $\underline{\text{m. 1}}$.
8. Outer aspect of right $\overline{\text{m. 1}}$.
9. A deciduous canine, probably from the upper jaw.
10. Outer aspect of left $\underline{\text{dm. 2}}$.
11. Inner and outer aspect of right $\underline{\text{dm. 3}}$.
12. Lower deciduous molars: $\overline{\text{dm. 2}}$ and $\overline{\text{dm. 4}}$ are seen from the outer side; $\overline{\text{dm. 3}}$ from the inner side.

Lettering as on Pl. IV, with the addition of—

i. Ridge on inner side of crown of $\overline{\text{c}}$.
j. Posterior cusp of $\overline{\text{pm. 2}}$.
n. Inner tubercle of $\underline{\text{dm. 3}}$.
o. Tubercle of $\overline{\text{dm. 4}}$.
p. Anterior root of $\underline{\text{m. 1}}$.
q. Posterior root of $\underline{\text{m. 1}}$.

The teeth shown in figs. 1 and 2 are from the Tor Bryan caves, near Torquay, and are now in the British Museum (Nat. Hist.). The other specimens, with the exception of those shown in figs. 5, 6, 7, and 9, are from the Creswell caves, Derbyshire, and are now in the Owens College Museum, Manchester. The tooth shown in fig. 9 is from Kirkdale cave, while the two shown in figs. 5, 6, and 7 are from Wookey Hole. These three latter specimens are all preserved in the Oxford Museum.



J. Green del. et lith.

Mintern Bros. imp.

Dentition.

PLATE VI.

Cave Hyæna.

Vertebræ.

(Natural size.)

Fig.

1. Atlas, dorsal aspect.
2. Axis.
3. Third cervical.
4. Fourth cervical.
5. Fifth cervical.
6. Sixth cervical.
7. Seventh cervical.

Figs. 2–7: All viewed from the left side.

a. Vertebrarterial canal.

b. Transverse process of atlas.

c. Posterior articulating surface of atlas.

d. Odontoid process.

e. Neural spine.

f. Anterior articulating surface of axis.

g. Postzygapophysis.

h. Posterior face of centrum.

i. Anterior face of centrum.

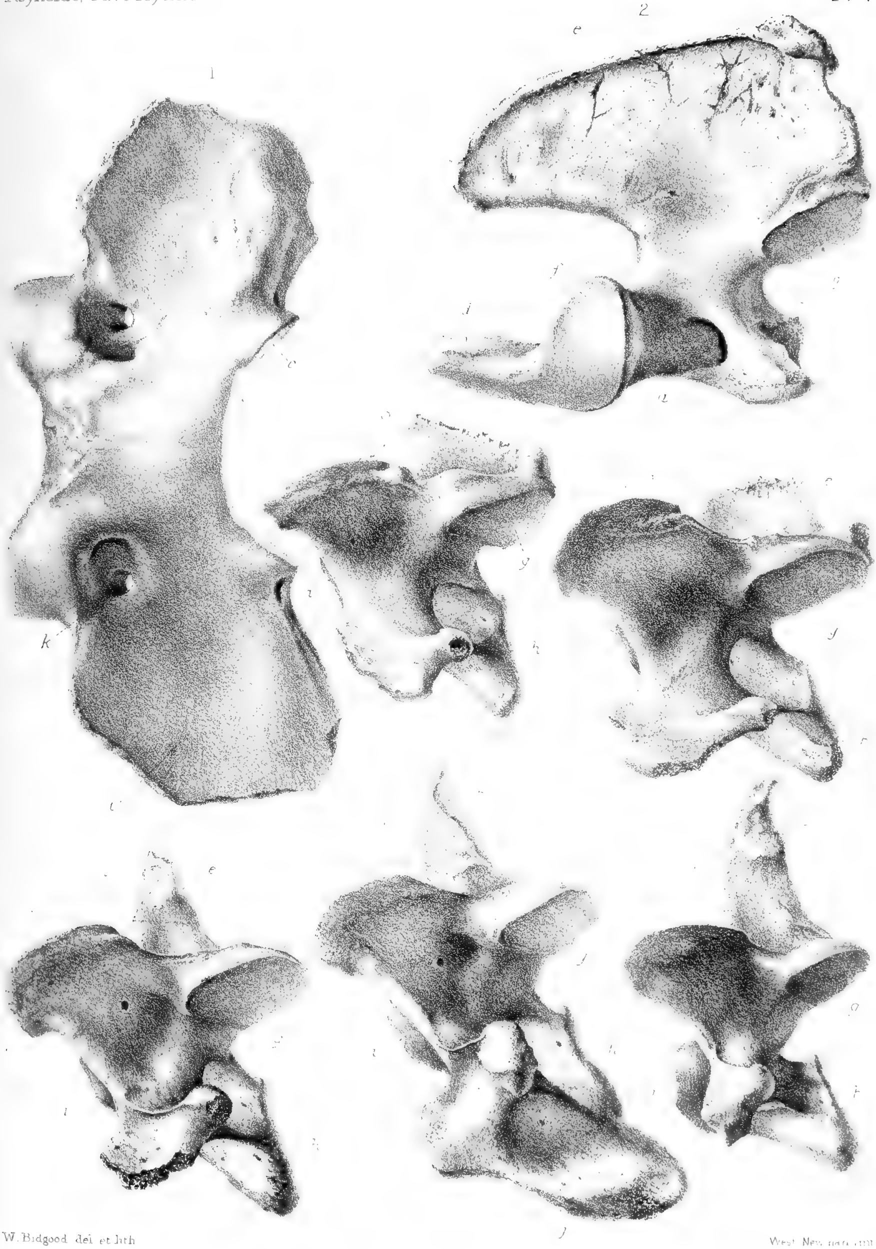
j. Inferior lamella of sixth vertebra.

k. Foramen for exit of spinal nerve.

All the above specimens are from Wookey Hole, Somerset, and are now preserved in the Taunton Museum. All except the atlas are from Skeleton A.

Reynolds, Cave Hyæna

Pl VI



W. Bidgood del et lith

West, Newman imp

PLATE VII.

Cave Hyæna.

Vertebræ.

(Natural size.)

Fig.

1. First thoracic, front view.
2. Second thoracic, seen from the left side.
3. Third thoracic, seen from the left side.
4. Fifth thoracic, front view.
5. Sixth thoracic, seen from the left side.
6. Tenth thoracic, front view.
7. Eleventh thoracic, seen from the left side.

a. Neural spine.
b. Neural canal.
c. Prezygapophysis.
d. Transverse process.
e. Anterior facet for articulation with capitulum of rib.
f. Posterior facet for articulation with capitulum of rib.
g. Notch for exit of spinal nerve.
h. Facet for articulation with tuberculum of rib.

All the above specimens are from Wookey Hole, and are now preserved in the Taunton Museum. Those shown in figs. 2, 3, and 5 are from Skeleton A; those shown in figs. 4, 6, and 7 are from Skeleton B.

W. Bidgood del. et lith

West Newman imp.

Vertebræ

PLATE VIII.

CAVE HYÆNA.

Vertebræ.

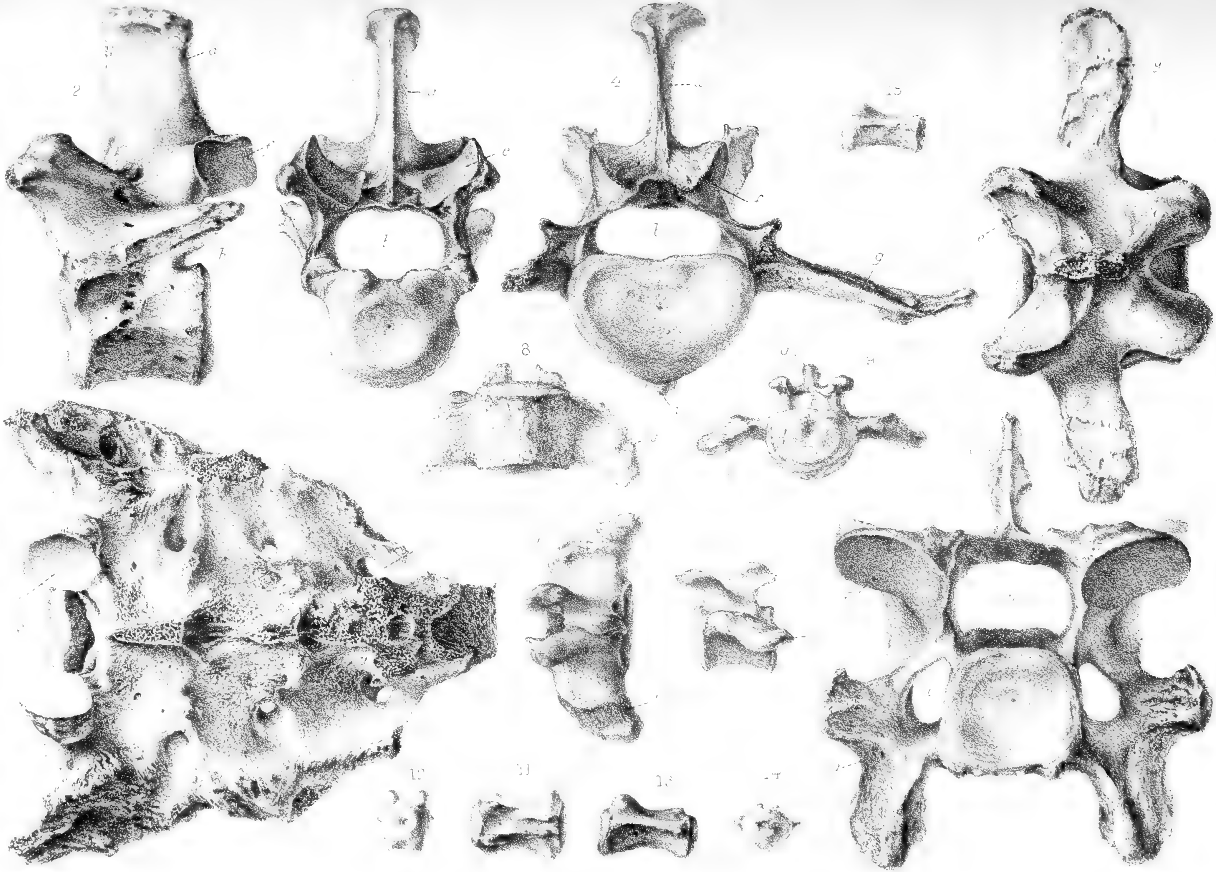
(Natural size.)

FIG.

1. Sixth cervical, posterior view.
2. Thirteenth thoracic, seen from the left side.
3. Thirteenth thoracic, front view.
4. Fourth lumbar, posterior view.
5. Fifth lumbar, dorsal view.
6. Sacrum, dorsal view.
7. Dorsal
8. Ventral $\Bigg\}$ view of the first free caudal vertebra.
9. Anterior
10. The same vertebra seen from the left side.
11. Dorsal
12. Anterior $\Big\}$ view of probably the ninth free caudal vertebra.
13. The same vertebra seen from the left side.
14. Anterior view of a late caudal vertebra, perhaps the twelfth.
15. The same vertebra seen from the left side.

a. Neural spine.
b. Neural canal.
c. Vertebrarterial canal.
d. Foramen in sacrum for exit of spinal nerve.
e. Prezygapophysis.
f. Postzygapophysis.
g. Transverse process.
h. Notch for exit of spinal nerve.

The specimens shown in figs. 1—6 are from Wookey Hole, and are preserved in the Taunton Museum. The other specimens figured are also without doubt from Wookey Hole, but I was unable to find them in the Taunton Museum. Figs. 1 and 4 are from Skeleton A; figs. 2, 3, and 6 from Skeleton B.



West, Newman imp.

Vertebræ

PLATE IX.

CAVE HYÆNA.

Scapula.

(Natural size.)

FIG.

1. Outer aspect } of left scapula.
2. Posterior aspect } of left scapula.

a. Glenoid cavity.

b. Acromion.

c. Prescapular fossa.

d. Postscapular fossa.

e. Glenoid border.

This specimen is from the Creswell caves, Derbyshire, and is now preserved in the Museum of Owens College, Manchester.

Green del. et lith.

Scapula

PLATE X.

Cave Hyæna.

Humerus, Ulna, and Radius.

(Natural size.)

Fig.

1. Right humerus,
2. Right ulna, all anterior aspect.
3. Right radius,

- *a.* Head of humerus.
- *b.* Great tuberosity.
- *c.* Lesser tuberosity.
- *d.* Deltoid ridge.
- *e.* Supra-trochlear foramen.
- *f.* Trochlea.
- *g.* External condyle.
- *h.* Internal condyle.
- *i.* Olecranon.
- *j.* Sigmoid notch.
- *k.* Surface for articulation with radius.
- *l.* Distal end of ulna.
- *m.* Surface for articulation with humerus.
- *n.* Distal end of radius.

The three bones are all from the Skeleton B found at Wookey Hole, and now preserved in the Taunton Museum.

Humerus, Ulna, and Radius.

PLATE XI.

Cave Hyæna.

Manus.

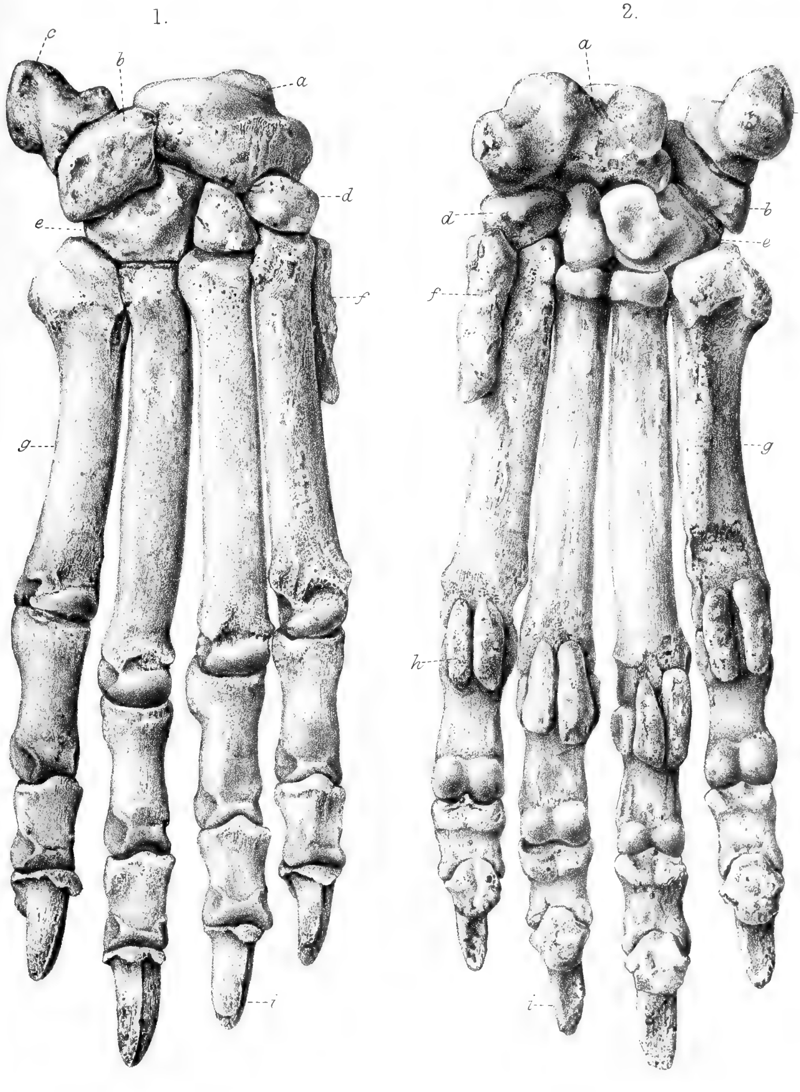
(Natural size.)

Fig.

1. Dorsal or anterior view of right manus.
2. Ventral or posterior view of right manus.

- *a.* Bone representing the fused scaphoid, lunar, and centrale.
- *b.* Cuneiform.
- *c.* Pisiform.
- *d.* Trapezoid.
- *e.* Unciform.
- *f.* First metacarpal.
- *g.* Fifth metacarpal.
- *h.* Sesamoid bone at metacarpo-phalangeal articulation of second digit.
- *i.* Ungual phalanx of third digit.

The specimens from which these figures were drawn are from the Tor Bryan caves, near Torquay, and are now in the British Museum (Nat. Hist.).



J. Green del. et lith.

Mintern Bros. imp.

Manus.

PLATE XII.

Cave Hyæna.

Pelvis.

(Natural size.)

Fig.

1. Left innominate bone, seen from the outer side.
2. Right innominate bone, seen from the inner or sacral side.

a. Acetabulum.
b. Obturator foramen.
c. Supra-iliac border of ilium.
d. Sacral surface.
e. Pubic border.
f. Ischial border.
g. Ischium.
h. Ischial tuberosity.
i. Pubis.

Both the above specimens belong to Skeleton A, found at Wookey Hole, and now in the Taunton Museum.

Reynolds, Cave Hyæna

Pl. XII.

West, Newman imp.

PLATE XIII.

CAVE HYÆNA.

Femur, Tibia, and Fibula.

(Natural size.)

FIG.

1. Right femur, viewed from the left side.
2. The same, proximal end.
3. The same, distal end.
4. Right tibia, anterior aspect.
5. The same, proximal end.
6. The same, distal end.
7. Right fibula, anterior aspect.
8. The same, proximal end.
9. The same, distal end.

a. Head of femur.

b. Great trochanter.

c. Lesser trochanter.

d. Outer condyle of femur.

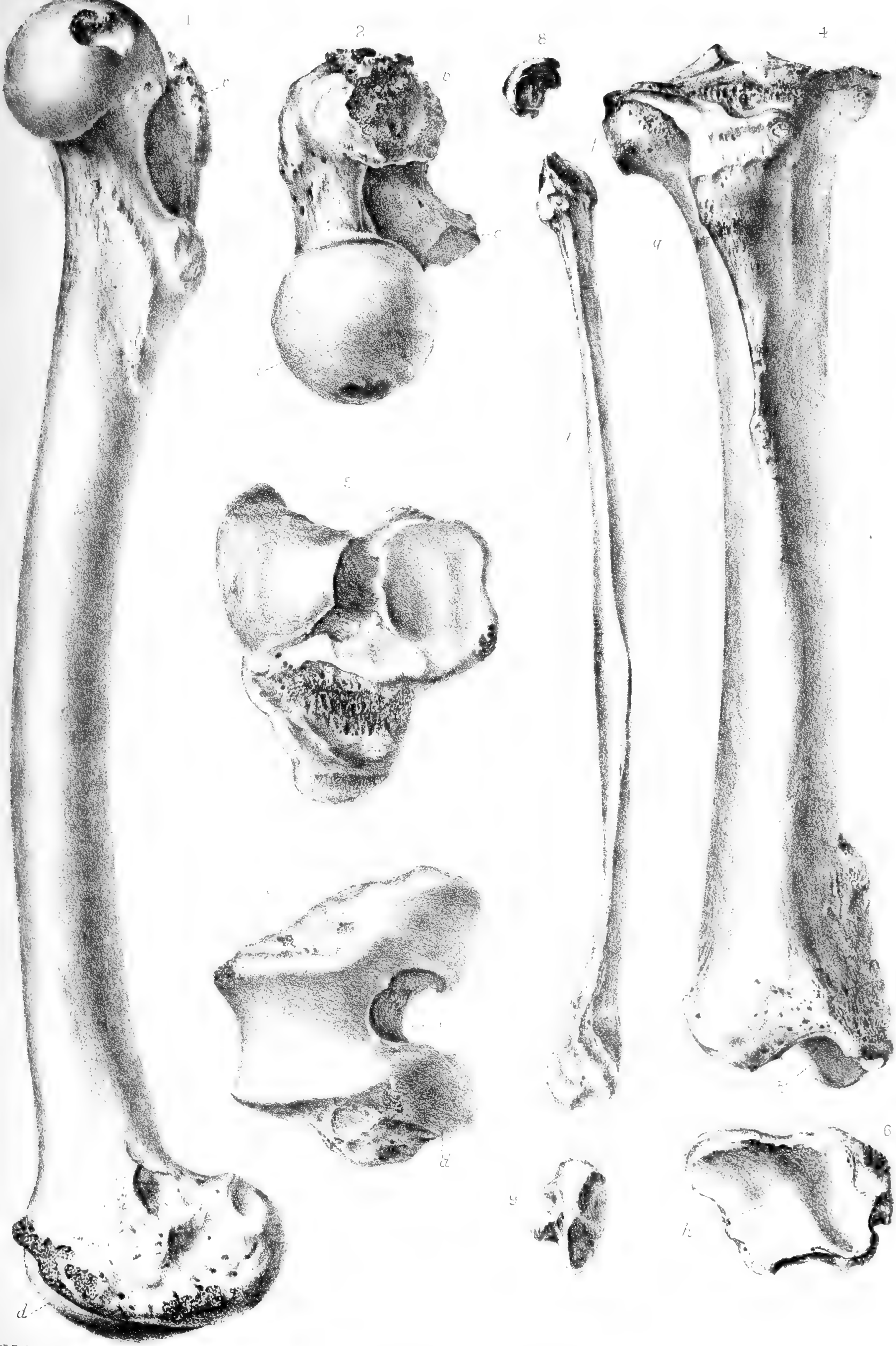
e. Intercondylar notch.

f. Surface for articulation with fibula.

g. Cnemial crest.

h. Surface for articulation with astragalus.

All the above specimens are from Wookey Hole, Somerset, and are now preserved in the Taunton Museum. The specimen from which figs. 1, 2, and 3 were drawn forms part of Skeleton A; the remainder are from Skeleton B.



W. Bidgood del et lith.

West, Newman imp.

Femur, Tibia, and Fibula

PLATE XIV.

CAVE HYÆNA.

Pes.

(Natural size.)

FIG.

1. Dorsal or anterior view of right pes.
2. Ventral or posterior view of the same.

a. Astragalus.

b. Calcaneum.

c. Cuboid.

d. Navicular.

e. External cuneiform.

f. Middle cuneiform.

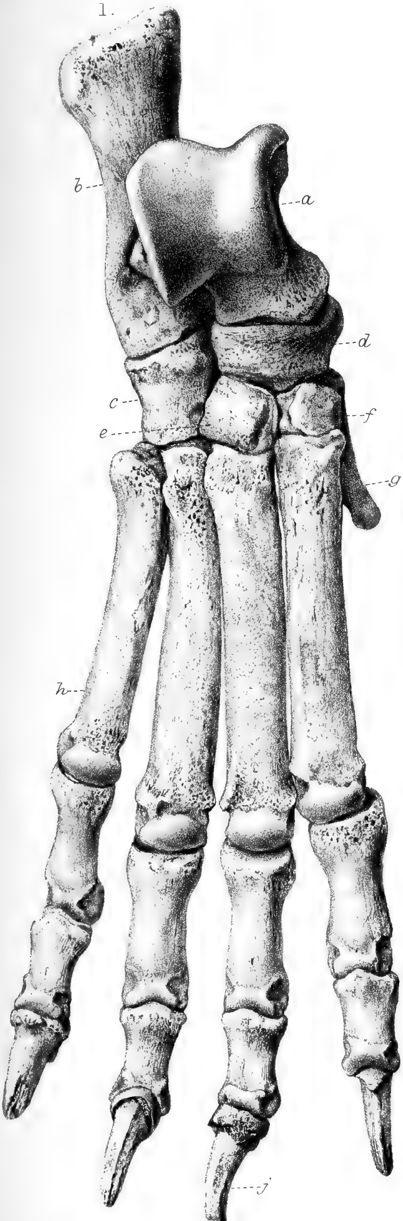
g. First metatarsal.

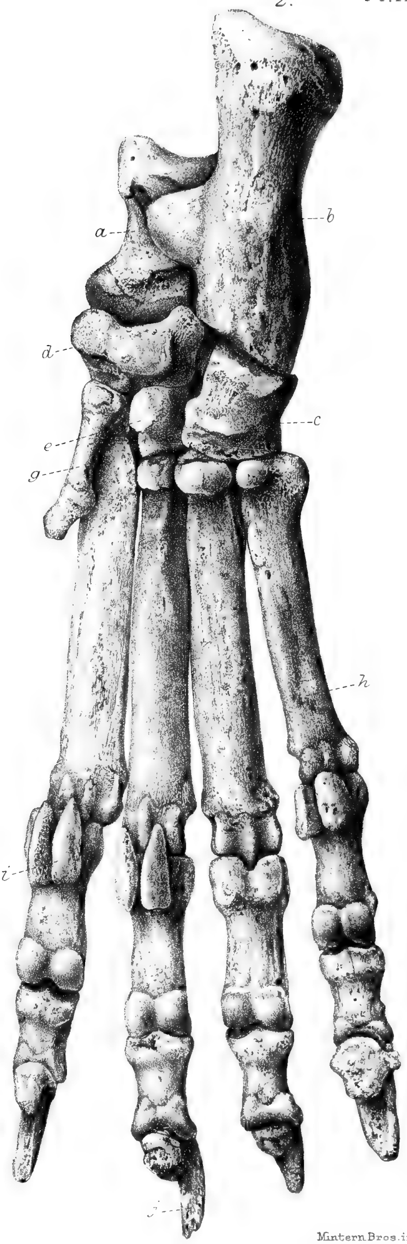
h. Fifth metatarsal.

i. Sesamoid at metacarpo-phalangeal articulation of second digit.

j. Ungual phalanx of third digit.

The specimens from which these figures were drawn are from the Tor Bryan caves, near Torquay, and are now in the British Museum (Nat. Hist.).





J. Green del. et lith.

Mintern Bros. imp.

Pes.

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THE

FOSSIL FISHES

OF THE

ENGLISH CHALK.

BY

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PART I.

PAGES 1—56; PLATES I—XIII.

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THE FOSSIL FISHES OF THE ENGLISH CHALK.

INTRODUCTION.

FISHES of the Cretaceous period are now known from many parts of the world. Materials are rapidly accumulating, indeed, for a tolerably complete account of the last of the Mesozoic fish-faunas. Some of the fossils, like those from the Lebanon, Dalmatia, and Westphalia, are whole fishes in a crushed state, displaying the vertebral column, fins, and scales, in undisturbed position, but showing almost nothing of the cranial osteology. Others, like those from the Chalk of England and Kansas, are usually more fragmentary, but are often little crushed, and exhibit the essential details of their osteology as well as modern skeletons. The specimens in these two conditions must therefore be carefully compared to obtain a complete knowledge of the various genera and species represented; and, as a basis for this comparison, it is necessary to prepare detailed descriptions and illustrations of each series of remains. So far as the fishes of the English Chalk are concerned, it is now proposed to attempt this preliminary work.

Fossil fishes seem to have been first noticed in the Chalk of this country by Dr. Gideon A. Mantell, who published general descriptions and figures of many specimens in his 'Fossils of the South Downs' in 1822. His collection was subsequently described with greater success by Agassiz in his 'Recherches sur les Poissons Fossiles' (1833–44). The writings of Mantell and Agassiz aroused so much interest in the south-east of England, that other collectors soon began to obtain important series of specimens, notably Dixon, Bowerbank, Willett (at that time named Catt), Coombe, Egerton, and Mrs. Smith, of Tunbridge Wells. Fine illustrations and brief notices of the Chalk fishes were then issued in Frederic Dixon's 'Geology and Fossils of Sussex' in 1850. A new edition of this work, with notes on the fossil fishes by E. T. Newton, appeared in 1878. Miscellaneous papers on certain genera were also published by Egerton, Günther, E. T. Newton, and W. Davies. More recently the present writer has made several contributions to the subject, including a preliminary "Synopsis" in the Proceedings of the Geologists' Association in 1888. Finally, there is a revised summary of all the known genera and

species from the English Chalk in the British Museum 'Catalogue of Fossil Fishes,' which was completed last year. All these writings will be referred to in due course.

The unique series of Chalk fishes collected by Mr. Henry Willett has been generously presented by him to the Brighton Museum; but all the other collections mentioned have been eventually acquired by the British Museum. To the latter are now added the fine collections made by S. H. Beckles, J. R. Capron, Frederick Harford, and S. J. Hawkins, besides smaller contributions from others. The Forbes-Young collection in the Woodwardian Museum, Cambridge, must also be specially mentioned; and the series of specimens obtained by the Right Hon. Lord Ashcombe from the Chalk near Dorking, is likewise of importance.

A large proportion of the fishes in some of these collections are unfortunately not labelled with the exact horizon and locality. The stratigraphical range of the various species and varieties, therefore, cannot yet be fixed so precisely as is desirable. The researches of Dr. Arthur W. Rowe [1] and Mr. G. E. Dibley [2] have contributed much towards our knowledge of the distribution of some forms; and the wide experience they have gained of the Chalk in the south of England enables them to determine with much probability of correctness the horizons of many specimens which lack exact labels. The writer is especially indebted to Mr. Dibley for his advice concerning the probable stratigraphical position of the fossils described from inland chalk-pits. Dr. Barrois [3] has already expressed his opinion that most of the specimens from the neighbourhood of Lewes described by Mantell and Agassiz, were obtained from the Turonian zones of *Terebratulina gracilis* and *Rhynchonella Cuvieri*.

Finally, it must be noted that in these fossil fishes the outer face of the bones and scales is often destroyed by flaking or by some solvent percolating through the chalk. Differences in the degree of external ornamentation need thus to be examined very critically with an experienced eye before they can be relied upon for the discrimination of species or races.

It is hoped that the fragmentary fossils will be rendered more easily comprehensible by the series of restored sketches in the text, which have been executed under the author's direction by Miss G. M. Woodward.

[1] A. W. Rowe, "The Zones of the White Chalk of the English Coast. Part I.—Kent and Sussex," Proc. Geol. Assoc., vol. xvi, 1900, pp. 289—368.

[2] G. E. Dibley, "Zonal Features of the Chalk Pits in the Rochester, Gravesend, and Croydon Areas," *loc. cit.*, vol. xvi, 1900, pp. 484—496.

[3] C. Barrois, "Recherches sur le terrain crétacé supérieur de l'Angleterre et de l'Irlande," Mém. Soc. Géol. Nord., vol. i, no. 1, 1876, p. 30.

SYSTEMATIC DESCRIPTIONS.

Subclass TELEOSTOMI.

Order ACTINOPTERYGII.

Suborder ACANTHOPTERYGII.

Family CARANGIDÆ.

Genus **AIPICHTHYS,** Steindachner.

Aipichthys, F. Steindachner, Sitzungsb. k. Akad. Wiss., math.-naturw. Cl., vol. xxxviii, 1859, p. 763.

Generic Characters.—Trunk much deepened, and head short and deep, with a large supraoccipital crest. Eye rather small; cleft of mouth oblique and wide, the

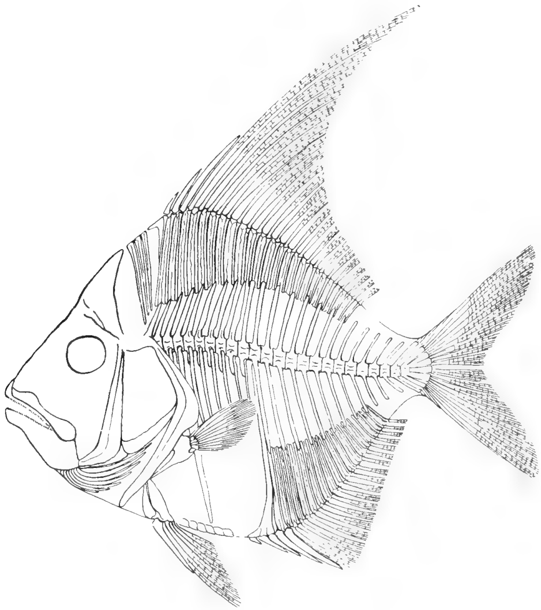

FIG. 1. *Aipichthys velifer*, A. S. Woodward; restoration of skeleton, without scales, about nat. size.—Upper Cretaceous; Hakel, Mt. Lebanon.

gape extending to the hinder border of the orbit; maxilla expanded behind; teeth minute but numerous. Pelvic fins inserted directly below the pectorals, somewhat

larger than the latter; dorsal fin much elevated and extending along nearly the whole of the back, with two to four very short and rather stout anterior spines; anal fin comparatively low, opposed to the hinder half of the dorsal, with three to five short and stout anterior spines; caudal fin deeply forked. Scales thin and small, except a series of ventral ridge-scales on the short abdominal region.

Type Species.—*Aipichthys pretiosus* (Steindachner, Sitzungsb. k. Akad. Wiss., math.-naturw. Cl., vol. xxxviii, 1859, p. 763, pl. i, fig. 1) from the Cretaceous (supposed Urgonian) of Comen, Istria.

Remarks.—This is the highest type of fish to which any specimen hitherto discovered in the English Chalk can be referred. The genus comprises small species, none more than 10 cm. in length, which are known by nearly complete skeletons crushed between the laminæ of the fissile Cretaceous limestones of Comen (Istria), the Isle of Lesina (Dalmatia), and Hakel (Mt. Lebanon). The specimens from Hakel were for many years ascribed to the allied genus *Platax*, which survives in existing seas. The accompanying restoration (Text-fig. 1) of the skeleton of *Aipichthys velifer*, however, shows that the fish differs from *Platax* in having a larger mouth, a much less elevated anal fin, and a deeply forked caudal fin. The thickened ventral ridge-scales also distinguish the Cretaceous from the Tertiary and Recent genus.

1. **Aipichthys nuchalis** (Dixon).

1850. *Microdon nuchalis*, F. Dixon, Geol. Sussex, p. 369, pl. xxxii, fig. 7.
1887. *Platax* (?) *nuchalis*, A. S. Woodward, Ann. Mag. Nat. Hist. [5], vol. xx, p. 342.
1901. *Aipichthys nuchalis*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, p. 429.

Type.—Imperfect fish, probably from zone of *Holaster subglobosus;* British Museum.

Specific Characters.—Not yet satisfactorily ascertained.

Description of Specimen.—This species is still known only by the unique type specimen, which is too incomplete to decide more than its generic relationships. Dixon's drawing of the fossil does not exhibit many of its essential features, but a study of the actual specimen reveals some of them. The supraoccipital bone of the cranium is shown to be raised into a large, laterally compressed, triangular crest. The vertebral centra, with their arches, are well ossified, and there seem to be only ten in the abdominal region. Of the pectoral fins no fragments remain, but each of the pelvic fins is represented by a single robust spine, though there are no traces of the articulated rays. Evidence of a much-elevated dorsal fin is seen in a series of large, wide-winged fin-supports above the vertebral column, just behind the supraoccipital crest. The anal fin is represented by its three small anterior spines. The total length of the fish cannot have exceeded 8 cm.

Horizon and Locality.—Probably zone of *Holaster subglobosus:* Washington, Sussex.

Family STROMATEIDÆ.

The Cretaceous genera provisionally assigned to this family are primitive Scombroid fishes of uncertain affinity.

Genus **BERYCOPSIS,** Dixon.

Berycopsis, F. Dixon, Geol. Sussex, 1850, p. 372.
Stenostoma, F. Dixon, *ibid.*, 1850, p. 373.

Generic Characters.—Trunk deepened and much laterally compressed. Cleft of mouth small and oblique, with minute clustered teeth; maxilla expanded behind, with relatively very large posterior supramaxilla; circumorbital plates small, except the foremost (antorbital), which is much expanded. Vertebræ about twelve in the abdominal, eighteen in the caudal region. Pectoral fins small and delicate; pelvic fins, with relatively large spine, inserted slightly behind the pectoral pair; dorsal and anal fins with a few very stout anterior spines, which gradually lengthen and are closely pressed together; caudal fin forked. Scales more or less feebly rugose and pectinated or ctenoid, extending over the operculum, occipital region, and cheek; none enlarged or thickened. Lateral line inconspicuous.

Type Species.—*Berycopsis elegans*, from the English Chalk.

Remarks.—This genus is most closely related to *Omosoma* and *Platycormus* from the Upper Cretaceous of the Lebanon and Westphalia. *Pycnosterinx*, from the Lebanon, may also perhaps prove to be an allied form when it is better known. *Omosoma* is distinguished by its cycloid scales, which seem to be less deepened on the flank than those of *Berycopsis;* while *Platycormus* appears to have about four more vertebræ and a much smaller pelvic fin-spine than the latter genus.

1. **Berycopsis elegans,** Dixon. Plate I; Plate II, fig. 1; Text-figure 2.

1850. *Berycopsis elegans*, F. Dixon, Geol. Sussex, p. 372, pl. xxxv, fig. 8.
1888. *Berycopsis elegans*, A. S. Woodward, Proc. Geol. Assoc., vol. x, p. 328.
1901. *Berycopsis elegans*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, p. 423.

Type.—Imperfect head and trunk from zone of *Holaster subglobosus;* Willett Collection, Brighton Museum.

Specific Characters.—The type species attaining a length of about 30 cm. Length of head with opercular apparatus considerably exceeding two-thirds the

maximum depth of the trunk, which nearly equals the length from the pectoral arch to the base of the caudal fin. External head-bones only partially rugose, the hinder expanded portion of the frontals being quite smooth, and the front edge of the supraoccipital crest not thickened or ornamented. Antorbital cheek-plate slightly deeper than broad, its depth about equalling that of the orbit. Dorsal fin with 6 short and stout spines, which are nearly smooth; anal fin arising much nearer to the pectorals than to the caudal. Scales very feebly rugose, or sometimes quite smooth, with slightly bent, not regularly curved hinder margin; nearly 30 scales in each transverse series on the abdominal region.

Description of Specimens.—The type specimen in the Brighton Museum does not exhibit many of the essential characters of the fish. It is, however, sufficiently complete for generic and specific determination. The gently rounded frontal region of the skull is shown, and the large supraoccipital crest is observable in transverse section. The operculum is much flaked, but seems to have been smooth. The scales are well displayed, exhibiting their proportions and the typical rhombic exposed area, with a very slight rugosity at its hinder border. The front part of the anal fin is preserved, and its remains extend to the hinder fractured edge of the fossil.

The only other important known specimens of this species are contained in the collection of the British Museum. All these are very imperfect; but two afford an approximate idea of the general proportions of the fish, while the others exhibit most of the principal characters of its skeleton.

The general proportions are best shown in the small specimen from the Chalk of Sussex represented of the natural size in Pl. I, fig. 1. The frontal profile of the head is steep, and the back gradually rises to the origin of the dorsal fin, where the trunk is deepest. The ventral margin of the body forms a more gentle curve than the dorsal border. The jaws are slightly pressed forwards in fossilisation, but, allowing for this, the length of the head with opercular apparatus is seen to equal its maximum depth at the back of the occipital crest. Its length also somewhat exceeds two thirds that of the trunk from the pectoral arch to the base of the caudal fin.

The roof of the skull is sharply bent above the middle of the large orbit, and its short hinder portion is surmounted by a deep triangular supraoccipital crest (Pl. I, figs. 1, 3, *socc.*), which is strengthened by one oblique ridge. The muscles of the trunk must have extended forwards over this portion of the skull as far as a sharp ridge which is inclined backwards on each side from the middle point at the hinder border of the frontal region (fig. 3, *fr.*). The frontal bones (*fr.*) are smooth and a little tumid, impressed with a few reticulating grooves, and by a pair of lateral, longitudinal sensory canals. There is also a large supraorbital flange (*spb.*), apparently of the same element, which bears a finely rugose ornamentation. Anteriorly the frontals taper, and overlap the narrow mesethmoid, which is almost

destroyed in the original of fig. 3, but is shown in other specimens, *e.g.*, the original of fig. 2. Its exposed portion is longer than broad, and gradually widens in front, where its anterior margin is deeply excavated by a re-entering angle. Its vertical extent is also considerable, as shown by an imperfect small specimen, B. M., no. P. 6049. The basioccipital region, as exposed in one specimen (B. M., no. P. 5683), is much laterally compressed, and there is a basicranial canal. The prefrontal or ectethmoid element (fig. 2, *prf.*) is seen to be large and deepened. There are sometimes remains of an ossified sclerotic.

The mandibular suspensorium is nearly vertical, only slightly inclined forwards; and the mandibular articulation is below the hinder margin of the orbit. The

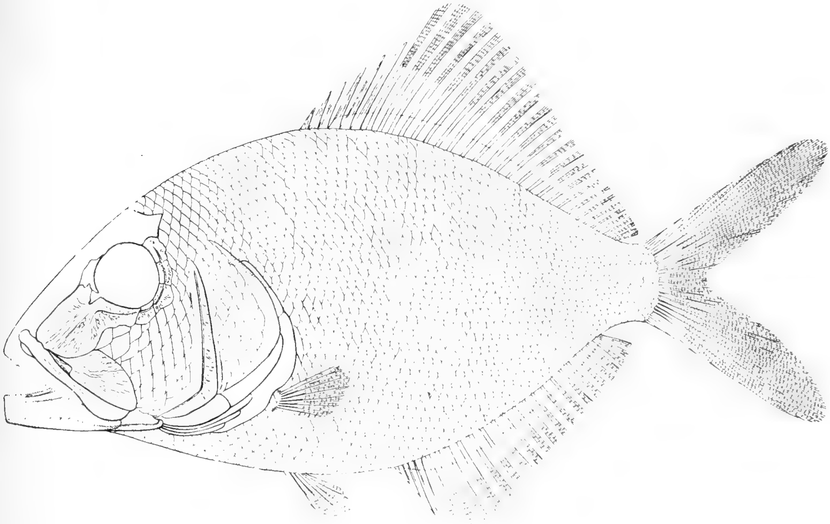

FIG. 2. *Berycopsis elegans*, Dixon; restoration, about one half nat. size.—English Chalk. The pelvic fins and the greater part of the anal and caudal fins are based on probabilities. The extent of the squamation over the rays of the dorsal and anal fins is indicated by a dotted line.

hyomandibular (fig. 2, *hm.*) is a long and narrow lamina, strengthened on the upper part of its outer face by three radiating ridges, one ending in the point of suspension (*s.*) for the operculum, the other two diverging respectively to the postero-superior and antero-superior angle of the bone. Its truncated lower end meets the symplectic and the hinder half of the upper margin of the quadrate. The latter element (*qu.*) is deeply notched for the reception of a rather large symplectic, and has the usual thickened articular prominence for the mandible below. The large and delicate laminar metapterygoid (*mpt.*) adjoins the anterior margin of the hyomandibular and the anterior half of the upper margin of the

quadrate; while the thin, arched, and tapering hinder portion of the ectopterygoid (*ecpt.*) borders the quadrate anteriorly and the metapterygoid inferiorly. As shown by B. M., no. P. 5683, the lower part of the inner face of the ectopterygoid bears a cluster of minute teeth. The premaxilla (figs. 1, 2, *pmx.*) completely excludes the maxilla from the upper border of the mouth on each side. It is remarkable for the great relative size of its anterior ascending process, which fits into the deep groove on the anterior face of the mesethmoid. It is constricted, though a little thickened, immediately behind the base of this process; and its oral face, when well preserved (*e. g.*, B. M., no. P. 5683), bears a broad cluster of minute teeth. The maxilla (figs. 1, 2, *mx.*) is a slender bar for the greater part of its length, with a large upturned anterior end, which is partly shown in fig. 1, but better preserved on the left side of the original of fig. 2. It terminates behind in a considerable laminar expansion which is broken and incomplete in the original of fig. 2, but a little less fractured in that of fig. 1. When quite complete, this expansion is slightly deeper than in the latter, and its outer face is not ornamented. The maxilla is overlapped for the greater part of its length by a relatively enormous supramaxilla (figs. 1, 2, *smx.2*), of which the form is best shown in fig. 2. It seems to have been slightly convex, and it is covered with a very fine rugose ornament, which is often partly destroyed in fossilisation. Below its anterior pointed prolongation there is also a diminutive second supramaxilla (fig. 2, *smx.1*), which is similarly ornamented. The mandible is more or less broken in all the known specimens, but its general shape is indicated in fig. 1. It is short and deep, with a truncated symphysis, and the oral border gradually rising to the coronoid region, of which the highest point is just in front of the articulation for the quadrate bone. The lower portion of the mandible is much bent inwards, so that its complete depth is not seen in direct side-view (figs. 1, 2). The dentary (*d.*) is quite smooth, but the articulo-angular (*ag.*) exhibits a horizontally-extended flattened ridge immediately below and in front of the articulation, covered with a fine rugose ornament. Below this ridge there is a deep groove, which may have been occupied by the slime-apparatus of the sensory canal. The thickened oral margin of the dentary bears clustered minute teeth like those of the premaxilla.

The cheek is covered partly by circumorbital plates, partly by scales. Most of the circumorbital plates (figs. 1, 2, *co.*) are small, and form a very narrow rim round the orbit; but the foremost element of the series, which may be termed antorbital (*ao.*), is excessively expanded. All these plates are covered with a very fine rugose ornament, and the sensory canal which traverses them is marked by a deep groove. The original outline of the large antorbital plate is best shown in fig. 2, where it is only destroyed by an accidental indent near the upper end of its hinder margin. Its maximum depth somewhat exceeds its width, and about equals the vertical diameter of the orbit. Its longer axis is slightly inclined

forwards, but its inclination is increased by crushing in the original of fig. 1. The sensory canal is abruptly bent downwards when it reaches the middle of this plate and spreads in a few radiating branches. When the cheek is well preserved it is seen to be completely covered with scales behind and below the circumorbital ring, and remains of these are observable in fig. 1. As shown by B. M. no. P. 6049, these scales are large and deeply overlapping, less conspicuously rugose than the circumorbital plates, and not serrated.

The opercular apparatus is complete. The preoperculum (figs. 1, 2, *pop.*) is very deep and narrow, and not much expanded at the angle, which is greater than a right angle. Its straight ascending limb tapers to its pointed upper end at the hyomandibular suspension of the operculum; its short lower limb is more bluntly pointed below. Its thickened anterior border overhangs the deep groove for the sensory canal; its narrow hinder wing, when well preserved, is covered with a fine rugose ornament but not serrated. The exact form of the operculum (*op.*) is difficult to determine, but it only seems to lack an insignificant fragment of the hinder border in fig. 1, and the postero-superior angle in fig. 2. In the former specimen it is completely exposed and exhibits only remains of a radiating rugose ornament in its hinder half. In better preserved specimens, however, as in the original of fig. 2, it is always covered with scales like those of the cheek, and its hinder ornamented portion is very little exposed. The suboperculum (*sop.*) and interoperculum (*iop.*) are narrow, antero-posteriorly extended bony plates, displaying a fine rugose ornament when well preserved, never covered with scales. The outline of these two elements seems to be complete in fig. 1, but the lower margin of the interoperculum is accidentally indented in fig. 2. Fragments of branchiostegal rays (*br.*) are seen in fig. 2, but these are imperfectly known. Three or perhaps four of them are shown on the right side in B. M. no. P. 6465. The branchial arches seem to bear a few large pointed gill-rakers (B. M. no. P. 5695).

The vertebral column is imperfectly known, but it comprises at least 26, perhaps as many as 30 vertebræ. The centra are much constricted cylinders, and most of them seem to be strengthened by a stout, lateral, longitudinal ridge. The arches are all very stout and large. The neural arches are fused with the centra in the abdominal, as well as in the caudal region. The anterior ribs articulate directly with the centra, but there may have been small transverse processes. There are expanded hypural bones (B. M. no. P. 6465).

The pectoral arch is suspended from the cranium by a small supratemporal (Pl. II, fig. 1, *st.*), and by a larger, forked post-temporal (*ptt.*). The supratemporal is an irregularly crescentic lamina, its concave border smooth and turned forwards, its convex border marked with a rugose ornament and turned backwards. Its antero-superior angle overlaps the epiotic, while its postero-inferior portion is in contact with the exposed laminar part of the post-temporal. This plate (*ptt.*) tapers a little above, but is truncated below where it articulates with the supra-

clavicle. The greater part of its outer face is smooth, but behind and below a deep vertical groove which traverses two thirds of its depth, it exhibits a rugose ornament. From its antero-inferior angle there extends forwards a smooth rod-like process (*p.*), which articulates with the pterotic. The supraclavicle (*scl.*) is more than three times as deep as broad, truncated above, tapering below, and with a thickened anterior margin. Its outer face is very feebly rugose. The clavicle (Pl. I, fig. 2, *cl.*) is much sigmoidally bent, with a large external lamina, which is as feebly ornamented as the supraclavicle. Its hinder margin is notched just above the attachment of the coraco-scapular mass (*c.*); and at the angle there is sometimes a trace of a post-clavicle (*pcl.*). There is a persistent suture between the coracoid and scapula, as shown on the left side of the original of Pl. I, fig. 2; and the scapula is pierced by a large oval foramen (*f.*). The basal bones of the pectoral fin are unknown, and the fin itself has never been well observed. As indicated by B. M. no. P. 6465, it is very small, comprising from eight to ten rays, of which the uppermost and longest cannot have exceeded the premaxilla in length. Only scattered fragments of its delicate fin-rays are shown in Pl. I, fig. 1, *p.* The pelvic fins are unknown, but a trace apparently of one of the supports in B. M. no. 37751, seems to show that their insertion was slightly behind that of the pectoral fins.

The median fins are always imperfect in the fossils, but some of their characters are observable. The dorsal fin seems to arise opposite the insertion of the pelvic pair, and is much extended. There are traces of free fin-supports in advance of it (Pl. I, fig. 1, *n.*); and its low anterior portion consists of very stout, nearly smooth, closely arranged spines (Pl. I, fig. 4). These spines, six in number, gradually increase in length, and are followed by much longer rays, which are closely articulated distally but only represented by their bases in the specimens figured (Pl. I, figs. 1, 4). The articulated dorsal rays must have been at least twenty-five in number, as shown by B. M. no. P. 6535. The anal fin must also have been considerably extended, arising in advance of the middle point between the pectorals and the caudal, and reaching at least as far back as the seventh vertebra from the caudal extremity. Its foremost support (Pl. I, fig. 1, *a*) exhibits at its lower end a large triangular expansion, evidently for the attachment of powerful spines. The caudal fin must have been delicate, and was probably forked. Only fragmentary remains of it are shown in Pl. I, fig. 1.

The aspect of the scales varies much in the different specimens, but this circumstance seems to be due to accidents in preservation. When they are undisturbed and complete, as in the front part of Pl. I, fig. 1, their exposed portion is observed to be almost rhombic in shape, the hinder border being not gently curved but rather sharply bent at its middle. When the surface is well preserved it is distinctly rugose, and some of the delicate markings at the hinder margin radiate in such a manner as to give it a pectinated appearance. The smoothness of the scales in the originals of Pl. I, figs. 1, 4, and in similar specimens, is almost certainly

due to the effect of some solvent on their outer face during fossilisation. No thickened or specially enlarged scales have been observed; and there are probably about 30 scales in each transverse series in the abdominal region. Their extension over the operculum and cheek has already been described. Small scales cover the muscular portion over the occipital and parietal region of the skull. There are also traces of them enveloping the base of the rays of the dorsal fin in the original of Pl. I, fig. 1, and in B. M. no. P. 6535. The lateral line is distinguishable, but only feebly marked.

Horizons and Localities.—Zone of *Holaster subglobosus*: Clayton, Sussex; Burham, Kent. Probably zone of *Rhynchonella Cuvieri*: Lewes, Sussex. Zone of *Holaster planus* or *Terebratulina gracilis*: Cuxton, Kent; Lewes.

2. **Berycopsis major,** sp. nov. Plate II, fig. 2.

Type.—Imperfect head and trunk; British Museum.

Specific Characters.—An imperfectly known species attaining a length of about 30 cm. Ornament of head and opercular bones more prominent than in the type species, extending over the hinder expanded portion of the frontals and the thickened front border of the supraoccipital crest. Antorbital cheek-plate not deeper than broad and less deep than the orbit. Scales with a regular ornament of delicate pectinations at the hinder border, which is gently and regularly curved; much larger and fewer than in the type species, there being less than 20 scales in each transverse series in the abdominal region.

Description of Specimen.—The unique specimen of this species is shown of the natural size in Pl. II, figs. 2, 2 *a*. It has been much broken, but displays many of the essential characters of the fish. The general proportions of the cranium do not differ much from those of the type species, but it is much more extensively ornamented and the median ethmoid is less exposed. The large triangular supra-occipital crest is only strengthened on its side by a slight ridge; but its anterior margin is thickened and was probably exposed, being marked with a fine longitudinal ridged ornament. The frontal region (*fr.*) is produced on each side into an overhanging supraorbital flange; and the rugose ornamentation is not confined to this, but extends in a radiating manner over nearly the whole of the hinder half of each frontal bone. The actual hinder limit of the frontals seems to be a straight, transverse line; while the small ornamented triangular area beyond this at each postero-lateral angle is doubtless to be regarded as belonging to the parietal (*pa.*). The small mesethmoid (fig. 2 *a*, *eth.*) has the same form as in *B. elegans*, but is more extensively covered by the frontals than in the latter species. The large, deep, antero-posteriorly compressed prefrontal or ectethmoid (*prf.*) is well shown, and is clearly articulated with the enlarged foremost plate of the circumorbital

ring (*ao.*). The mandibular suspensorium and palato-pterygoid arcade are much obscured; but, so far as they are exposed, they resemble the corresponding parts of the type species. The premaxilla (*pmx.*) lacks its hinder end on both sides of the fossil, but displays the very large anterior ascending process. It has a sharp lower edge, but a broad flattened oral face to bear a cluster of minute teeth. The maxilla (*mx.*) is also imperfect on both sides, but is represented on the right by its anterior and posterior extremities. Its anterior end is turned upwards in a stout process, while its posterior portion expands into a large, smooth lamina. Only the hinder supramaxilla (*smx. 2*) is preserved, and it may perhaps be a little broken at its upper border. It is ornamented with a very conspicuous rugosity, of which the main ridges extend antero-posteriorly. The mandible appears exactly as described in the type species, and the dentary (*d.*) is shown to have borne a broad band of clustered minute teeth. The hour-glass-shaped ceratohyal (fig. 2, *ch.*) is short and deep, with a broad lamina of bone connecting its upper angles. It (perhaps with the small epihyal, which is covered) supports five branchiostegal rays (*br.*). The circumorbital plates (*co.*) are ornamented and deeply grooved, and all except one are very small, as in *B. elegans*; but the enlarged foremost plate of the series, which is imperfect on the right side (*ao.*), is much less deepened than in the latter species. Its maximum depth is indeed less than the vertical diameter of the orbit, and, as shown on the left side, its lower border is feebly pectinated or serrated. Abraded and broken rugose scales remain covering the cheek behind and below the circumorbital ring. The opercular apparatus closely resembles that of *B. elegans*, but is more strongly ornamented. In the fossil only three or four of the scales which originally covered the operculum are preserved. Behind the opercular bones, a little displaced and imperfect, are observed the characteristic post-temporal (*ptt.*), supraclavicle (*scl.*), and clavicle (*cl.*,) with part of the scapula (*sc.*) pierced by the usual oval foramen. The destruction of some scales also exposes a few of the stout ribs (*r.*). The right pelvic fin (*plv.*) is shown slightly behind the pectoral arch. Its large and stout anterior spine is fractured and fragmentary, but seems to have been as long as the succeeding articulated rays, of which only four are seen. The anal fin spines (*a.*) are also very stout and slightly ornamented by longitudinal ridges. They seem to have been four in number, rapidly increasing backwards in size and length. The base of only one articulated ray is preserved behind them in the fossil. The scales are relatively large, with a gently and regularly rounded posterior border. The abraded rugose ornament of their exposed portion has often a pitted appearance, but at the posterior border it passes into regular pectinations. The scales cannot be exactly counted, but there were probably less than 20 of them in any transverse series on the abdominal region. The lateral line (*ll.*) forms a little smooth triangular prominence on the covered portion of each scale which it traverses.

Horizon and Locality.—Probably zone of *Holaster planus*: Cuxton, Kent.

Type specimen obtained by Joseph Wood for Frederick Harford, Esq., who prepared it.

3. **Berycopsis pulchella** (Dixon).

1850. *Stenostoma pulchella*, F. Dixon, Geol. Sussex, p. 373, pl. xxxvi, fig. 2.
1888. *Stenostoma pulchella*, A. S. Woodward, Proc. Geol. Assoc., vol. x, p. 329.
1901. *Berycopsis, sp.*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, p. 425.

Type.—Imperfect fish; British Museum.

Specific Characters.—An imperfectly known very small species, resembling *B. major* in the form of the antorbital and scales, but apparently with rather more than 20 scales in a transverse series on the abdominal region, and supramaxilla feebly ornamented.

Description of Specimen.—The unique type specimen of this species represents a fish only about 8·5 cm. in length, and is very unsatisfactorily figured by Dixon, *op. cit.* The orbit is unusually large and surrounded by the characteristic circumorbital plates, of which the antorbital is seen to resemble that of *B. major* in form and proportions. The hinder expansion of the maxilla is quite smooth; while the rather low, large supramaxilla is only faintly rugose, and an impression on the chalk seems to indicate that it was not truncated but tapering behind. A fragment of the outer face of the operculum displays the ridged ornament; and scales are observed to extend over both this bone and the cheek. Traces of the base of the dorsal and caudal fins are seen. Most of the scales are preserved in undisturbed series, and their pectinations terminate in a rather conspicuously serrated hinder border.

The relatively large size of the orbit, and the prominence of the scale-ornament are characters suggesting the immaturity of the fish now described.

Horizon and Locality.—Probably zone of *Holaster subglobosus*: Steyning, Sussex.

An undetermined species of *Berycopsis* from the Grey Chalk (zone of *Holaster subglobosus*) of Dover is also indicated by part of a small trunk in the British Museum (no. 49062).

Family BERYCIDÆ.

Genus **HOPLOPTERYX**, Agassiz.

Hoplopteryx, L. Agassiz, Poiss. Foss., vol. iv, 1838, p. 4.

Generic Characters.—Trunk much deepened and laterally compressed, with lower face of abdominal region flattened. Frontal region of skull deeply ridged

for slime-cavities; cleft of mouth little oblique, and jaws with minute clustered teeth; orbit small or of moderate size; preoperculum without spine, only serrated; operculum produced into two short and broad spines at its hinder margin. Vertebræ about 10 in the abdominal, 14 in the caudal region. Pelvic fins arising below or somewhat behind the origin of the pectorals, with one stout spine and 6 to 8 divided rays. Dorsal fin much extended, its anterior half consisting of 5 to 9 stout spines, not closely pressed together; anal fin comparatively short, with 3 to 5 stout spines, not closely pressed together; caudal fin more or less forked. Scales pectinated, rather large, and none much enlarged or thickened; lateral line forming a conspicuous discontinuous ridge.

Type Species.—Hoplopteryx antiquus (Agassiz, *tom. cit.*, p. 131, pl. xvii, figs. 6—8) from the Senonian of Westphalia.

Remarks.—The species of this genus from the English Chalk have commonly

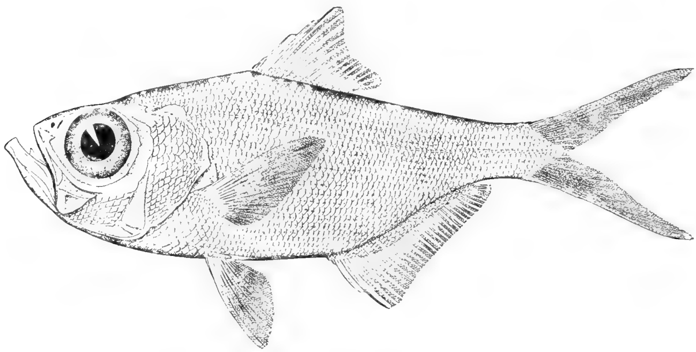

FIG. 3. *Beryx splendens*, Lowe; much reduced from nat. size.—Existing in deep sea. After Goode and Bean.

been referred to the surviving genus *Beryx*. They are indeed characterised by a peculiarly ridged skull with slime-cavities disposed almost as in *Beryx* (Text-fig. 5). *Hoplopteryx*, however, is clearly distinguished from the latter by its much smaller eye, the greater extent of the spinous portion of its dorsal fin, and the less extent of its anal fin. The differences will be readily appreciated on comparing the accompanying Text-fig. 3 with Text-fig. 4 opposite.

1. **Hoplopteryx lewesiensis** (Mantell). Plate III; Plate IV, fig. 1; Plate VII, fig. 1; Text-figs. 4, 5 B.

1822. *Zeus lewesiensis*, G. A. Mantell, Foss. S. Downs, p. 234, pls. xxxv, xxxvi.

1835–39. *Beryx ornatus*, L. Agassiz, Poiss. Foss., Feuill., p. 55, and vol. iv, p. 115, pl. xiv *a*, pl. xiv *b*, figs. 1, 2, pl. xiv *c*, figs. 1, 3—6 (*non* fig. 2), pl. xiv *d* (exc. fig. 2).

1850. *Beryx ornatus*, F. Dixon, Geol. Sussex, p. 371, pl. xxxiv, fig. 1, pl. xxxvi, figs. 1, 3.

1888. *Hoplopteryx lewesiensis*, A. S. Woodward, Proc. Geol. Assoc., vol. x, p. 327.

1901. *Hoplopteryx lewesiensis*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, p. 397, pl. xvi, fig. 4, text-fig. 13.

Type.—Imperfect fish, probably from one of the Turonian zones; British Museum.

Specific Characters.—A species attaining a length of about 30 cm. Length of head with opercular apparatus considerably less than the maximum depth of the trunk, which nearly equals the length from the hinder margin of the clavicle to the base of the caudal fin. Tubercular and rugose ornament of external bones rather fine. Operculum twice as deep as broad. Dorsal fin occupying nearly one half of the back, comprising 6 very stout, longitudinally ribbed spines and 8 to 10

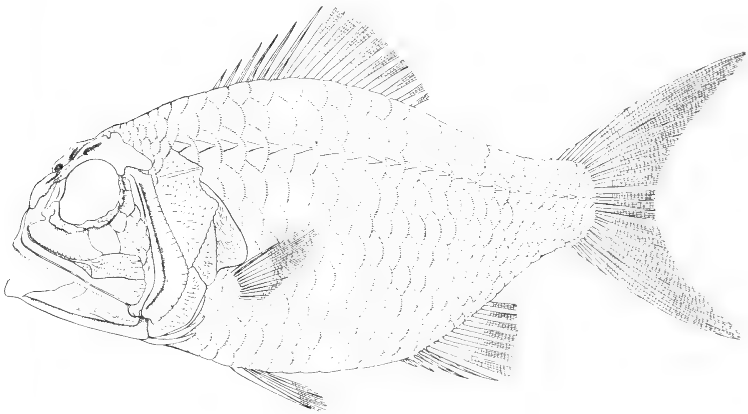

Fig. 4. *Hoplopteryx lewesiensis*, Mantell; restoration, about one half nat. size.—English Chalk.

divided rays, the length of the longest spine almost equalling one third the depth of the trunk at its insertion; anal fin with 7 or 8 divided rays preceded by 3 or 4 very stout spines, which gradually increase to a length about equalling that of the longest dorsal. Scales very finely rugose and delicately pectinated; the lateral line traversing about the ninth longitudinal series above the ventral border.

Description of Specimens.—The type specimen in the Mantell Collection (nos. 4014–15) is too imperfect to exhibit many of its generic and specific characters; but, on direct comparison, it is clearly proved to be specifically identical with certain better-preserved fossils on which the foregoing diagnosis is based. Part of the left side of the head and opercular apparatus is exposed from within, and the operculum shows its two characteristic spines. The imperfect trunk is a little distorted and shows only fragments of the vertebral column and median fins, with

the four anal fin-spines distinctly borne by separate supports. Some of the large, thin, serrated scales are well displayed, while the thickenings and bendings produced by the sensory canal of the lateral line are also conspicuous. The general proportions of the fish, noted in the specific diagnosis and indicated in the accompanying restoration (Text-fig. 4), are better shown by the original of Pl. III, fig. 1, and by many similarly preserved specimens. As proved by B. M. no. 49043, the lower border of the abdominal region is gently rounded or flattened, not keeled.

The cranium (Pl. III, fig. 2; Text-fig. 5 B) closely resembles that of *Beryx* (Text-fig. 5 A), especially in the arrangement of the ridges and hollows on the

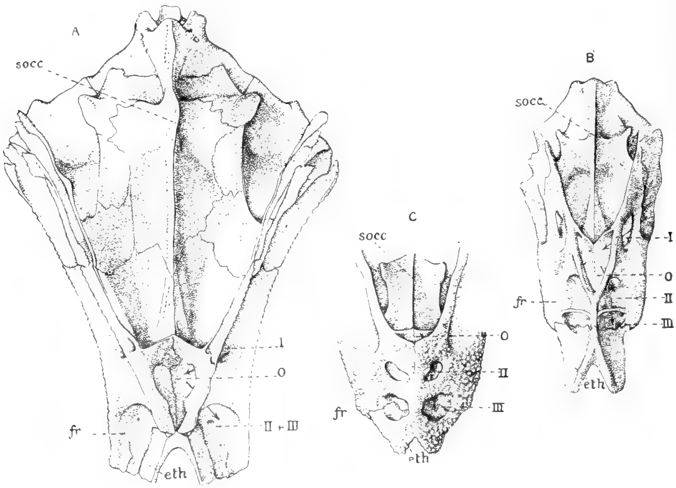

Fig. 5. Roof of cranium of *Beryx decadactylus*, Cuv. and Val. (A), *Hoplopteryx lewesiensis* (Mantell) (B), and *Hoplopteryx simus*, A. S. Woodw. (C). *eth.*, mesethmoid; *fr.*, frontal; *socc.*, supraoccipital crest in fossa originally occupied by muscles; O, median slime-cavity; I, II, III, lateral paired slime-cavities; arrows indicating passages through the walls of the slime-cavities.

roof; but the ethmoidal region is relatively larger than in this existing genus. The parasphenoid is slender, and there is a large basicranial canal (B. M. nos. P. 5687–88). The occipital plane is inclined backwards and downwards; and the low median supraoccipital crest (*socc.*) is produced backwards over it. As in *Beryx*, the supraoccipital with its crest is sunk in a deep trough formed by a pair of laminar ridges (Pl. III, fig. 2, *r.*), which are deepest behind on the otic region and gradually converge forwards until they meet in a short median ridge at the anterior end of the frontal region. Again as in *Beryx*, this large median trough is crossed by a less elevated transverse ridge in its anterior narrow portion; and the small triangular cavity thus formed (O) opens into the lateral frontal cavities by two

foramina piercing the bounding ridge on each side. Muscles covered by scales (B. M. no. 49043) occupied the greater part of the trough just described, but the small anterior triangular portion must have been a slime-cavity. The frontal bones (Pl. III, fig. 2, *fr.*) extend from the hinder border of the orbit to the front margin of the prefrontal or ectethmoid, where they meet the mesethmoid (*eth.*) in a jagged suture. They form a slight supraorbital flange on each side, marked with a coarse, tubercular ornament at the border. Internal to this flange and external to the great ridge already described, they are transversely ridged to produce three pairs of lateral slime-cavities, which are connected with each other by foramina piercing the bounding walls. The largest or anterior cavity (II, III) is again bridged by a thin spicule of bone at the anterior end of the frontal, as shown in the restoration (Text-fig. 5 B). This delicate bridge is lacking in most fossils, as in the original of Pl. III, fig. 2; but it is indicated in nos. 49038, P. 1948 *b*, and other specimens in the British Museum. The mesethmoid (*eth.*) is as long as broad, entirely in advance of the frontals, and impressed in front with a deep groove for the reception of the ascending processes of the premaxillæ. The prefrontal or ectethmoid is very deep and narrow. When well preserved, all the sharp ridges of the cranial roof, except the supraoccipital, are observed to be ornamented on the edge with a row of tubercles; and similar tubercles are seen on the lateral borders of the mesethmoid.

The mandibular suspensorium is nearly vertical, the gape of the mouth extending just behind the eye. The hyomandibular (Pls. III, VII, fig. 1, *hm.*) is deep and narrow, and its outer face bears a large, thin laminar ridge bordering the anterior edge of the preoperculum, as in *Beryx*. A small symplectic bone (*sy.*) is exposed on the outer face of the suspensorium, and fits in a notch of the quadrate (*qu.*). The palato-pterygoid arcade is partly shown in fig. 1 of Pls. III and VII, but is much obscured in both and incomplete at its upper margin in the latter, where the entopterygoid is wanting. It evidently resembles the corresponding arcade of *Beryx*, but the inner face of the deep laminar palatine (*pl.*) bears a more extended patch of minute teeth, which is continued on the anterior end of the ectopterygoid (*ecpt.*). The premaxilla (*pmx.*) completely excludes the maxilla from the upper border of the mouth on each side, but only a very narrow margin is exposed when the maxilla rests naturally upon it. The straight oral border of the bone is widened and bears a broad band of minute, blunt teeth throughout its length, well seen from the inner aspect in Pl. III, fig. 3. Its overlapped middle portion is produced upwards into a small, thin wing (fig. 1, *pmx.*, fig. 3); while its anterior end is sharply upturned in a forked process. The maxilla (*mx.*) is almost or quite smooth, with a large, sharply upturned process in front, and a small triangular expansion behind. Its anterior process bears at the upper extremity a convex facette for articulation with the palatine; and the hinder half of the upper border of the bone is overlapped by two supramaxillæ. Of these the posterior

plate, imperfectly preserved in the original of Pl. III, fig. 1 (*smx. 2*), is quadrangular, almost twice as long as deep, and marked on its outer face by rows of coarse tubercles and rugæ, which are mainly disposed in an antero-posterior direction. Its antero-superior angle is produced forwards into a sharply pointed stylet above the very small, triangular anterior supramaxilla (*smx. 1*), which is similarly ornamented. The mandible is deep, especially in the coronoid region, and the lower half of its outer face, immediately above the tuberculated lower edge, is impressed with a deep, continuous fossa for the slime-canal. Above this fossa the longitudinal median ridge is coarsely tuberculated, especially where it expands a little on the angular bone (*ag.*) and exhibits a disposition of the tubercles in oblique rows directed downwards and backwards. Above this ridge the bone is again smooth, and the widened, overhanging edge of the dentary (*d.*) bears a band of minute, blunt teeth like those of the premaxilla.

The deep and large hyoid arch, seen from the inner side in Pl. VII, fig. 1 (partly shown also in Pl. III, fig. 1), is suspended from the lower end of the hyomandibular (*hm.*) by a long and slender stylohyal or interhyal (*ih.*). The triangular epihyal (*eph.*) is relatively small; and the large ceratohyal (*ch.*) has a broad plate of bone connecting the two upper extremities of the ordinary hour-glass-shaped element. The short and deep hypohyal (*hy.*) is subdivided into two pieces by a transverse suture, the larger piece being below. Fragmentary remains of a large, thin, laminar urohyal are also observable in several specimens. The whole arch is indeed closely similar to that of *Beryx*.

The greater part of the cheek is covered by the ring of circumorbital plates (Pl. III, fig. 1, *co.*), which are small and narrow behind the eye but much extended below. Their orbital margin is everted and tuberculated, while their lower margin, immediately above the maxilla, is clearly serrated; but the middle portion of all the plates is quite smooth and forms a deep channel for the reception of the slime-apparatus. The shape of the relatively large anterior circumorbital is well shown in Pl. III, fig. 1 (*ao.*); and it appears to have been articulated with the prefrontal. Scales are very rarely seen on the cheek behind the circumorbital ring, but they seem to have been present (B. M. no. 25863).

The opercular apparatus is complete, and satisfactorily observed both in Pl. III, fig. 1, and in a specimen described and figured in the 'Catal. Foss. Fishes Brit. Mus.,' pt. iv, p. 400, pl. xvi, fig. 4. The preoperculum (*pop.*) tapers to the upper end of the hyomandibular and gradually curves forwards at its lower end, without much expansion of the rounded angle. It is deeply grooved for the slime-canal, and the two thin edges of the bone bounding this fossa are delicately serrated. The operculum (*op.*) is much deeper than wide, and its hinder border is produced into two short and broad spines, of which the upper is connected by a strong ridge with the point of suspension. Its outer face is marked with a tubercular and rugose ornament radiating from the same point. The suboperculum, almost want-

ing in the original of Pl. III, fig. 1, is relatively small and triangular in shape, with a prominent anterior ascending process. It is ornamented like the operculum. The interoperculum (*iop.*) is of remarkable extent, and more coarsely ornamented with slightly radiating tuberculated ridges. Nine branchiostegal rays have been distinctly observed (B. M. no. 49043).

The vertebral column comprises 10 (or perhaps 11) vertebræ in the abdominal region, and 14 vertebræ in the caudal region. It is essentially similar to that of *Beryx*, and the greater part of it, with imperfect arches, is shown in the original of Pl. IV, fig. 1. The foremost vertebral centra (wanting in fig. 1) are very short and deep, without transverse processes, but with stout neural spines sharply pointed at the upper end. The five posterior abdominal vertebræ, with centra as long as deep, bear laminar transverse processes, which are inclined downwards as well as outwards, and increase in size backwards. Their neural spines are antero-posteriorly compressed, so appear very thin in side-view in fig. 1. The ribs are rather slender. The posterior abdominal centra, like the caudals, are impressed by two large lateral pits separated by a broad median longitudinal ridge, which is also impressed by smaller longitudinally-extended pits. The neural and hæmal arches in the caudal region are stout and sharply inclined backwards; and a specimen figured by Agassiz, *tom. cit.*, pl. xiv *d*, fig. 3, shows the characteristic expansion of the arches at the base of the tail. The penultimate and antepenultimate hæmal spines seem to form stouter expansions than in *Beryx*.

The pectoral arch is suspended from the cranium by a large post-temporal, of which only a fragment is shown in Pl. III, fig. 1, *ptt.* The greater part of this element is a thin vertical lamina, with curved and serrated upper border, strengthened by a ridge on its inner face (Pl. VII, fig. 1, *ptt.*), and connected with the epiotic by a slender bar (B. M. nos. P. 5688, P. 5694). It exhibits a thickened articulation with the supraclavicle (*scl.*), which is deeper than broad, with a straight and thickened anterior border. The upper half of the sigmoidally-bent clavicle (Pl. III, fig. 1, *cl.*), above the pectoral fin, is expanded into a thin lamina, which is about twice as deep as broad and ornamented with fine vermiculating ridges—finer than those on the opercular bones. The long, rod-shaped post-clavicle almost reaches the ventral border of the fish (B. M. no. P. 5692). The small scapula (Pl. III, fig. 1) is pierced by an oval foramen. The pectoral fin-rays (*pct.*) are comparatively delicate, probably short and about eleven in number. Of the pelvic fins only a fragment is shown in Pl. III, fig. 1, *plv.* When apparently complete, each is observed to comprise a stout spine and six articulated rays, the latter scarcely if at all longer than the former. The dorsal fin (Pl. III, fig. 1, *do.*) arises above the insertion of the paired fins, and was evidently not subdivided. Its anterior portion consists of six spines, which gradually increase in length backwards, are longitudinally ridged or fluted, and are borne by very stout winged supports. These spines are imperfect in the original of Pl. III, fig. 1, and in most

specimens; but when complete the length of the longest spine nearly equals one third the maximum depth of the trunk, and its length seems to be scarcely exceeded by that of the foremost of the articulated rays, which were probably about eight to ten in number. The anal fin arises slightly nearer to the pelvic pair than to the caudal fin and is provided with four fluted spines (Pl. III, fig. 4), which gradually increase in length so that the longest is about as large as the longest dorsal spine. Beyond the spines only fragments of articulated rays are seen in Pl. III, fig. 4; but another specimen in the British Museum (no. 49036) clearly exhibits seven supports for such rays in its anal fin. The caudal fin has never been completely observed, but some specimens show that it must have been forked.

The scales are large, thin, and deeply overlapping; and those of the flank are deeper than broad. Their hinder border is gently rounded and very finely pectinated, but the greater part of their exposed face is delicately rugose. Their inner face sometimes exhibits a few tuberculations. The number of scales in a transverse series on the flank of the abdominal region is about 11. The course of the lateral line is marked by a smooth triangular prominence on each scale of the series traversed, which is the ninth from the ventral border in the abdominal region (Pl. III, fig. 1, *ll.*).

Horizons and Localities.—Zones of *Holaster subglobosus* to *Terebratulina gracilis*: neighbourhood of Lewes, Sussex; neighbourhood of Burham, Kent. Zone of *Holaster subglobosus*: Folkestone and Dover, Kent. Zone of *Terebratulina gracilis*: Cuxton, Kent. Zone of *Micraster cor-testudinarium*: Purley and Guildford, Surrey.

2. **Hoplopteryx superbus** (Dixon). Plate IV, figs. 2, 3; Plates V, VI; Plate VII, figs. 2—5.

1850. *Beryx superbus*, F. Dixon, Geol. Sussex, p. 372, pl. xxxvi, fig. 5.
1887. *Hoplopteryx superbus*, J. W. Davis, Trans. Roy. Dublin Soc. [2], vol. iii, p. 514.
1888. *Hoplopteryx superbus*, A. S. Woodward, Proc. Geol. Assoc., vol. x, p. 328.
1901. *Hoplopteryx superbus*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, p. 403.

Type.—Imperfect fish from one of the Turonian zones; British Museum.

Specific Characters.—A large species, attaining a length of about 45 cm., with fins apparently similar to those of *H. lewesiensis* but the trunk slightly more elongated and the scales relatively larger and more strongly ornamented than in the latter species. Operculum less than twice as deep as broad. Lateral line traversing the sixth or seventh longitudinal series of scales above the ventral border.

Description of Specimens.—The type specimen in the Dixon Collection (B. M. no. 25959), from Southeram, near Lewes, shows the greater part of the trunk with remains of the median fins, and is imperfectly represented of half the natural size

in Dixon's figure. The maximum depth of the trunk is shown to be considerably less than the length from the pectoral arch to the base of the caudal fin; and the origin of the dorsal and anal fins is seen to be as in *H. lewesiensis.* The large characteristic scales are much abraded, so that they appear pitted and their hinder pectinations are fainter than they are proved to have been by better-preserved specimens. The lateral line clearly passes along the sixth or seventh longitudinal series above the ventral border; and it is conspicuously marked by small, smooth, triangular eminences chiefly on the covered part of the scales traversed. The general form of the fish in side-view is better shown by another specimen in the British Museum, which is represented of one-half the natural size in Pl. IV, fig. 3. The trunk is much laterally compressed as usual; but, when seen from below (Pl. IV, fig. 2), the ventral face of the abdominal region is observed to be flattened as far back as the pelvic fins (*plv.*), whence the ventral border forms an acute ridge to the origin of the anal fin (*a.*).

Some of the principal characters of the head are exhibited by the distorted specimen represented in Pl. VI. The large triangular depression at the back of the cranium is distinct, and the small, thin crest of the supraoccipital (*socc.*) rises from its floor. Traces of the small scales investing this region are also seen. The supraorbital flange of the frontal bone (*spb.*) is conspicuous, though imperfect at the edge; and the tubercular ornament of the cranial roof seems to have resembled that of *H. lewesiensis.* The jaws agree precisely with those of the latter species, except that there are some traces of tubercles along the exposed edge of the anterior half of the maxilla (*mx.*). Another specimen, on the slab photographed in Pl. V, shows that there are minute clustered teeth on the palatines and also on the thickened end of the vomer, as in *Beryx.* The large lower circumorbital plate in the specimen figured (*ao.*) appears similar to that of *H. lewesiensis;* but other examples (*e. g.*, Pl. VII, fig. 2) seem to show that, when unbroken, the everted edge of this plate is relatively wider than in the latter species and rather finely tuberculated. On the cheek behind and below the circumorbitals there are small pectinated scales, as indicated by remains of a second fish preserved on the same block of chalk as the specimen figured. The anterior ridge of the preoperculum (*pop.*) seems to exhibit a slightly sharper bend at the angle than in *H. lewesiensis;* and the operculum (*op.*) is a little wider in proportion to its depth than in the latter species. The sharp indent between the two flat spines of the operculum is also noteworthy. Its ornamentation is more variable than usual in species of *Hoplopteryx.* Sometimes the discontinuous oblique ridges and tubercles shown in Pl. VI become fused into smooth and regular, nearly parallel ridges (as on one operculum in the left lower corner of Pl. V). Sometimes there are fine vermiculating rugæ between the prominent ridges (B. M. no. P. 3982). Seven branchiostegal rays are exhibited by one specimen on the slab represented in the photograph, Pl. V, and there may have been more.

The vertebral column is partly shown in Pl. VI, and so far as preserved in this and other specimens it closely resembles that of *H. lewesiensis*. The anterior abdominal vertebræ are clearly destitute of transverse processes. The ribs are rather stout (B. M. no. P. 7653).

The outer plate of the clavicle (Pl. VI, *cl.*) exhibits an ornament in its hinder half as coarse as that of the operculum. The lower portion of the bone is much expanded into a transverse lamina (B. M. no. P. 9153). The pectoral fin seems to have been as small and delicate as in *H. lewesiensis*. The pelvic fin has a very stout, ribbed anterior spine followed by seven articulated rays. The bases of only six of these rays are seen in Pl. VI, *plv.*, but the complete number is indicated in Pl. IV, fig. 2, *plr.* The dorsal fin is imperfectly known, but in the type specimen its anterior portion evidently consists of about six very stout, ribbed spines, and these are followed by at least seven equally stout articulated rays. The anal fin comprises four ribbed spines and seven articulated rays (B. M. no. 39431). Of the caudal fin only fragments are known.

The scales are large, rather thick, and deeply overlapping; and those of the flank are deeper than broad. Their overlapped portion has a truncated anterior border, towards which a few grooves radiate from the centre of the scale, as shown in Pl. VII, figs. 3, 4. Their exposed portion, when unabraded, is coarsely rugose and strongly pectinated at the posterior border, as indicated in the same figures. Their inner face bears a cluster of large, rounded tubercles, as shown in the counterpart of the type specimen (Pl. VII, fig. 5). There are about 24 transverse series of scales on the trunk, each comprising 10 or 11 scales, of which the sixth or seventh above the ventral border is traversed by the lateral line. Some small scales, as already mentioned, extend over a portion of the cheek; and a few are seen covering part of the antero-superior margin of the operculum (B. M. nos. 39431, P. 7653).

The greater part of a unique slab of chalk in the Beckles Collection (B. M. no. P. 9153), covered with remains of several individuals of *Hoplopteryx superbus*, is shown of one half the natural size in the photograph, Pl. V. These fishes seem to have been suddenly destroyed and rapidly buried before there was much opportunity for decay. The principal specimen near the middle of the slab displays a widely gaping mouth, and the head partly torn from the trunk. Nearly all the specimens retain their original rotundity. A ventral view of the fish at the lower border of the slab is given in Pl. IV, fig. 2, already described.

Horizons and Localities.—Zones of *Rhynchonella Cuvieri* and *Terebratulina gracilis*: neighbourhood of Lewes, Sussex. Probably same zones in Burham district, Kent.

3. **Hoplopteryx simus,** sp. nov. Plate VIII, figs. 1—4; Text-figure 5 c.

1837–39. *Beryx ornatus*, L. Agassiz (*errore*), Poiss. Foss., vol. iv, p. 117, pl. xiv *d*, fig. 2.

Type.—Imperfect head; British Museum.

Specific Characters.—An imperfectly known species, probably not exceeding 20 cm. in length. Length of head with opercular apparatus considerably less than the maximum depth of the trunk. Tubercular and rugose ornament of external bones very coarse, the rounded tubercles being especially large on the shortened snout. Operculum twice as deep as broad. Scales moderately thick, with short but coarse pectinations at the hinder border; all the scales smaller than usual in the genus, probably almost 20 in a transverse series on the trunk; the lateral line traversing about the fourteenth longitudinal series above the ventral border.

Description of Specimens.—The type specimen (B. M. no. 49073) displays remains of a head of the typical *Hoplopteryx*-type, with unusually coarse and strongly-developed ornament, which is very conspicuous on the shortened snout, and is so much developed on the lower part of the mandible as to form bridges over its slime-canal and thus partially subdivide it (Pl. VIII, fig. 3). A similar head in association with remains of the greater part of the trunk (B. M. no. P. 387) shows that the fish must have had much the same proportions as *H. lewesiensis*, with an inferiorly-flattened abdominal region.

Other imperfect examples of the head in the British Museum display nearly all its principal characters, and show the curiously shortened form of the cranium (Text-fig. 5 c). A fracture in B. M. no. P. 5700 reveals evidence of a basicranial canal. The smooth floor of the extensive depression of which the supraoccipital forms a large part, is exhibited in one specimen (Pl. VIII, fig. 1, *socc.*); and its lateral bounding wall, ornamented externally at the upper edge by large rounded tubercles, is shown in other specimens (*e. g.*, Pl. VIII, fig. 2, *r.*). In advance of the anterior apex of this cavity the frontals (fig. 1, *fr.*) are thickened by a mass of large, smooth tubercles, which cluster round a pair of anterior frontal slime-pits (II) and spread outwards into a similar tuberculation and thickening of the supraorbital flange. The mesethmoid (*eth.*), which is about twice as broad as long, completes the cranium in front, with a re-entering angle for the ascending processes of the premaxillæ. Its anterior and lateral borders are also much thickened by a cluster of large rounded tubercles, which bound another pair of slime-pits (III). These are somewhat larger than the anterior frontal pits, and each is directly connected with the latter of the same side by a foramen through the intervening barrier, which evidently corresponds with the thin spicular bridge of bone occupying the same position in *H. lewesiensis*.

The mouth is as large as in *H. lewesiensis*, but there are differences in the shape

and ornamentation of the bones. The middle portion of the premaxilla (figs. 1, 1 *a*, *pmx.*) is less elevated into a prominence than in the latter species. The posterior supramaxilla (fig. 1 *a*, *smx. 2*) is about three times as long as deep; while its ornament of longitudinal rugæ and tubercles is continued over the outer face of the maxilla (*mx.*). The mandible exhibits its usual ornamented ridge; but the ornament consists of very large tubercles, which extend over a series of bridges spanning the longitudinal slime-canal to the lower border of the jaw. The mandibular slime-canal thus appears as if it were subdivided into a series of pits (fig. 3).

There are six branchiostegal rays attached to the right ceratohyal of the type specimen.

The circumorbital cheek-plates exhibit their usual development (fig. 1 *a*, *co.*); but the everted rim of the lower circumorbital (*ao.*) which is coarsely tuberculated, is notably wide. The inferior margin of this circumorbital bears oblique pectinations. The postero-inferior part of the cheek is covered with small scales (*s.*), which are thickened by a few coarse pectinations and tubercles at their hinder border.

The opercular apparatus is more coarsely ornamented than in *H. lewesiensis*, and the hinder border of the operculum (fig. 2, *op.*) is curiously excavated immediately above its large spine. Between the main ridges of the ornamentation there are also very fine vermiculating ridges, of which those on the operculum are chiefly directed downwards and backwards.

The anterior part of the vertebral column is partly shown by a specimen in the Mantell Collection (no. 4004), which is figured by Agassiz, *tom. cit.*, pl. xiv *d*, fig. 2. This fossil clearly belongs to *H. simus*, although the head is very fragmentary and most of the ornamented face of the outer bones is destroyed. The vertebræ exposed resemble those of *H. lewesiensis*, but the four anterior caudal centra are perhaps a little shorter and deeper than in the latter species.

The fins are only known by unsatisfactory fragments; but one specimen (B. M. no. P. 387) seems to show that the pelvic, dorsal, and anal fins were situated as in *H. lewesiensis*, while there were six ribbed dorsal spines. The same specimen shows part of the squamation. The scales are smaller than usual in the genus, and there were probably about twenty in each transverse series on the flank of the abdominal region. The lateral line (Pl. VIII, fig. 4, *l.*) forms a very prominent smooth ridge on each scale of about the fourteenth longitudinal row above the ventral border. The hinder margin of the scales is usually destroyed, but when well preserved it bears a few short, coarse pectinations.

Horizons and Localities.—Probably zone of *Holaster subglobosus*: neighbourhood of Burham, Kent; Dorking, Surrey; Clayton, Sussex. Probably a Turonian zone: Lewes, Sussex. One specimen in the Brighton Museum (Willett Collection no. 63) is labelled "Upper Chalk, Brighton."

Genus **HOMONOTUS**, Dixon.

Homonotus, F. Dixon, Geol. Sussex, 1850, p. 372.

Generic Characters.—Trunk deepened and laterally compressed, with rounded ventral border. Frontal region of skull not deeply ridged; jaws with minute clustered teeth; orbit small or of moderate size; preoperculum without spine, only serrated; operculum produced into one long spine behind. Pelvic fins, with one spine and 6 divided rays, arising below the origin of the pectorals; dorsal fin much extended, its anterior portion comprising at least 12 long and slender spines, which are not pressed closely together; anal fin with 4 large spines. Scales pectinated, rather large and thin, none much enlarged or thickened; lateral line forming a conspicuous ridge.

Type Species.—*Homonotus dorsalis* from the English Chalk.

1. **Homonotus dorsalis,** Dixon. Plate VII, figs. 6, 7; Plate VIII, figs. 6, 7.

1850. *Homonotus dorsalis*, F. Dixon, Geol. Sussex, p. 372, pl. xxxv, fig. 2.
1888. *Homonotus dorsalis*, A. S. Woodward, Proc. Geol. Assoc., vol. x, p. 329.
1901. *Homonotus dorsalis*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, p. 408.

Type.—Imperfect fish from Malling, Sussex; Willett Collection, Brighton Museum.

Specific Characters.—The type species, probably attaining a length of about 15 cm. Length of head with opercular apparatus less than the maximum depth of the trunk and exceeding half its length from the pectoral arch to the base of the caudal fin. Length of longest dorsal fin-spines equalling about half the maximum depth of the trunk, and longest anal fin-spine somewhat shorter. About 13 scales in a transverse series on the abdominal region, those of the ventral half the more strongly ornamented.

Description of Specimens.—This is a rare species known by the type in the Brighton Museum, by a small series of specimens in the British Museum, and by three others in the collection of Dr. H. P. Blackmore, Salisbury.

The general proportions of the fish may be inferred from the type and from two imperfect specimens in the British Museum, nos. 43264 and P. 1952 *a*. There is also an imperfect small fish from the zone of *Holaster subglobosus* at Burham (B. M. no. 41673), which may perhaps be an immature individual of the same species. No. 43264 is shown of the natural size in Pl. VIII, fig. 7, and is somewhat elongated by the distortion of the head and tail. The head with opercular apparatus is about as long as deep. Its length equals less than the maximum depth of the trunk, but more than half the length from the pectoral arch to the

base of the caudal fin. The depth of the caudal pedicle seems to be contained nearly three times in the maximum depth of the abdominal region. The fish must have been much laterally compressed.

As shown by the type specimen and by B. M. no. P. 1952*a*, the head in side-view is triangular, with a sharply pointed snout. The cranium is bent above the middle of the orbit; and its short hinder portion, over which the muscles originally extended, is surmounted by a deep and triangular, laminar, median longitudinal crest (Pl. VIII, fig. 6, *socc.*). The frontal profile is steep and straight. The frontal bones are partly shown from above in Pl. VIII, fig. 7 (*fr.*), and do not bear any large slime-cavities. The orbit is not very large, its depth being less than half that of the head without the crest. The cheek-plates are imperfectly known; but there is a large anterior suborbital (Pl. VIII, figs. 6, 7, *ao.*), which is ridged on its outer face by the radiating branches of the sensory canal and is strongly serrated on its lower margin. The mandibular suspensorium is inclined forwards so that the articulation of the mandible is not behind the middle of the orbit. The long, slender premaxilla (Pl. VIII, fig. 6, *pmx.*) completely excludes the maxilla (*mx.*) from the gape, as usual; and the latter element terminates behind in a smooth triangular expansion, which is smaller in a typical specimen (B. M. no. 33230) than in the doubtful small fish from Burham (Pl. VIII, fig. 6, *mx.*). The large hinder supramaxilla is ornamented with longitudinal rugæ on the left side of B. M. no. 33230, while in the Burham specimen it is smooth (*smx.*). When well preserved, as in no. 33230 (Pl. VII, fig. 7, *md.*), the mandible exhibits a deep, longitudinally extended fossa on its outer face for the accumulation of slime round the sensory canal. The bounding ridges are coarsely crenulated. The teeth are minute, uniform in size, and clustered in both jaws.

The opercular apparatus is best known by fragments on the right side of B. M. no. 33230. The preoperculum is deep and narrow, curved rather than sharply bent at its angle, which does not bear a spine. It is traversed by a deep groove for the sensory canal, and the bounding ridges are coarsely though regularly serrated. The operculum, also partly shown on the left side of the same specimen (Pl. VII, fig. 7, *op.*), must have been shaped nearly like that of *Hoplopteryx*, but with only one long and acute spine projecting from its hinder margin in the upper portion. Its outer face is covered with delicate rugæ which tend to radiate backwards and downwards; and with this ornament are interspersed in the hinder half a few short radiating ridges, of which the largest passes into the prominent spine. The suboperculum is not satisfactorily known, but the interoperculum is ornamented with coarse radiating ridges. Five branchiostegal rays are observable, but there were probably more.

The vertebral column seems to comprise 10 vertebræ in the abdominal region, and probably about 14 in the caudal region. So far as known, the vertebræ resemble those of *Beryx* and *Hoplopteryx*. A few of the caudals are especially

well exposed in B. M. no. 39074, and the separate laminar neural spines at the base of the caudal fin are seen (Pl. VII, fig. 6).

In the pectoral arch the clavicle is much expanded above the base of the fin, and this exposed lamina (Pl. VII, figs. 6, 7, *cl.*) is ornamented with fine rugæ which pass into coarser pectinations at its hinder border. Only slight traces of the pectoral fin have been observed, and it must have been small and delicate. The pelvic fins are inserted directly beneath the pectoral pair, and distinctly comprise seven robust rays, of which the foremost seems to be a stout, longitudinally ridged spine (Pl. VII, figs. 6, 7, *plv.*). The length of these rays is indicated by remains in the original of Pl. VIII, fig. 7 (*plv.*). The median fins are only known by fragments, and the total number of rays is uncertain. The counterpart half of a specimen in the Dixon Collection (B. M. no. 25910) appears to show that there are 12 dorsal fin-spines, all slender and impressed with at least one longitudinal groove. The first 5 or 6 spines gradually increase in length; and the length of the others equals about half the maximum depth of the trunk. The proportions of some of these spines are shown in Pl. VII, figs. 6, 7, and Pl. VIII, fig. 7. The spines of the anal fin (Pl. VII, figs. 6, 7, *a.*) are rather stouter than those of the dorsal fin. They are four in number, with separate supports (Pl. VIII, fig. 7, *a.*), and gradually increase in length to the fourth, which is not so long as the longest dorsal spines. The articulated rays in the dorsal and anal fins are scarcely known, but two specimens show that the extent of the anal fin equalled at least the length of nine vertebræ. The caudal fin is also known only by fragments (*e.g.*, Pl. VIII, fig. 7, *c.*), but it must have been rather large and forked.

The scales (Pl. VII, fig. 6 *a*) are large, thin, and deeply overlapping; none extend over the head or fins. Their number seems to be about thirteen in a transverse series on the flank of the abdominal region. Their hinder border is gently rounded, and their exposed face is marked with radiating pectinations, which are most conspicuous on the ventral scales of the abdominal region. As shown by the original of Pl. VII, fig. 7, the ventral border is rounded, without modified ridge-scales. The course of the lateral line is marked by a rounded ridge on each of the scales traversed, and this ridge is still prominent quite at the end of the caudal pedicle (Pl. VII, fig. 7).

Horizons and Localities.—The type specimen seems to have been obtained from the zone either of *Rhynchonella Cuvieri* or of *Terebratulina gracilis* at Malling, near Lewes, Sussex. The small specimen in the British Museum, already mentioned, was probably found in the zone of *Holaster subglobosus* at Burham, Kent. The species, however, occurs more commonly in one of the higher zones of the Chalk, probably in that of *Micraster coranguinum*: Bromley, Northfleet, and Gravesend, Kent; Micheldever, Hampshire. It has also been obtained by Dr. H. P. Blackmore from the zone of *Actinocamax quadratus* at East Harnham, and from the *Uintacrinus*-band of the zone of *Marsupites* near Salisbury.

2. **Homonotus rotundus,** sp. nov. Plate VII, fig. 8.

Type.—Distorted fish; British Museum.

Specific Characters.—A smaller species than the type of the genus with more deepened trunk. Length of longest dorsal fin-spines not exceeding one-third the maximum depth of the trunk; fourth anal fin-spine at least as long as the longest dorsal fin-spine.

Description of Specimens.—This small fish is known by two small specimens in the British Museum, the largest (no. P. 5682) representing an individual perhaps 10 cm. in total length, with a maximum depth of about 4 cm. The dorsal region of another fish as large as the latter is also preserved in Mr. Dibley's collection.

The type specimen, which is much distorted, is shown of the natural size in Pl. VII, fig. 8. Its head is almost destroyed, the remains only comprising recognisable portions of the pectinated antorbital. The trunk must have been originally almost orbicular with a much contracted caudal pedicle. The vertebral column is distorted, but so far as it can be compared, it resembles that of *H. dorsalis*. The dorsal fin (*d.*) clearly extends along the greater part of the back, and its anterior portion consists of 12 slender spines, each marked with a longitudinal groove and fixed to a winged support. The foremost four of these spines rapidly increase in length, the next four are about equal, and the last four are slightly the longest. The length even of the latter must have been contained at least three times in the maximum depth of the trunk. Behind the spines there seem to be traces of not less than 15 articulated dorsal fin-rays, arranged in a series extending quite to the base of the contracted caudal pedicle. Among the remains of the anal fin (*a.*) the fourth anterior spine is well preserved, and it is as long as either of the four hindermost dorsal fin-spines. It is followed by not less than 13 articulated rays, and the anal fin must have terminated exactly opposite the end of the dorsal fin. The scales are large and thin, as usual, and some of them exhibit traces of their hinder pectination.

The larger specimens already mentioned do not display any additional characters of the species. B. M. no. P. 5682 exhibits the triangular supraoccipital crest of the skull.

Horizons and Localities.—The type specimen was obtained by the late Mr. Harris of Charing from Page's Pit, Westwell, near Charing, Kent, and evidently belongs to the zone of *Holaster subglobosus*. The larger specimen, from the Harford Collection, is of uncertain origin. Mr. Dibley's specimen was discovered in the zone of *Holaster subglobosus*, Blue Bell Hill, Burham.

Genus **TRACHICHTHYOIDES,** novum.

Generic Characters.—Frontal region of skull depressed and flattened, with a shallow, antero-posteriorly elongated, rhombic depression occupying its middle portion; ethmoidal region very small; mouth small, with minute clustered teeth; orbit of moderate size; preoperculum without spine, only serrated; operculum irregularly triangular in shape, its hinder margin being produced into one very prominent broad spine. Scales pectinated, extending over the cheek.

Type Species.—*Trachichthyoides ornatus*, from the Chalk of Kent.

Remarks.—This genus is as yet known only by the head, which seems to have been very similar to that of the existing genera *Trachichthys* and *Gephyroberyx*, but lacks the preopercular spine.

1. **Trachichthyoides ornatus,** sp. nov. Plate VIII, fig. 5.

Type.—Imperfect head; British Museum.

Specific Characters.—Maximum width of cranium slightly exceeding half its length; cranial ridges and supraorbital border finely rugose and tubercular. Maximum width of operculum equalling two-thirds of its depth.

Description of Specimen.—The unique fossil on which this species is founded, is shown of the natural size from the left lateral and superior aspects in Pl. VIII, figs. 5, 5 *a*. The cranium is well preserved, shown a little obliquely in fig. 5, directly from above in fig. 5 *a*. The parietal-squamosal region is very short, and there is no supraoccipital crest rising above the plane of the flattened cranial roof. The occipital plane slopes backwards and downwards. The large frontal bones (*fr.*) are divided by a persistent median suture, and do not taper in front, where each is obliquely truncated. Each expands at the outer side into a supraorbital flange, and this is connected by a ridge with a bent longitudinal ridge, which bounds a shallow slime-cavity in the middle of the cranial roof. Another short ridge extends from the chief frontal ridge to the pterotic region; and on the floor of a shallow slime-cavity in the anterior half of the frontal bone an oval vacuity is conspicuous. The supraorbital border and all the ridges are ornamented with fine though prominent tubercles and vermiculating rugæ. A fragment of the mesethmoid (*eth.*) proves this element to have been comparatively small and narrow. Remains of the circumorbital ring of cheek-plates (*co.*) exhibit a broad, everted orbital rim, which is ornamented like the ridges of the cranium and overhangs a deep channel for the slime of the sensory apparatus. The largest plate beneath the eye is serrated on its lower edge. Behind and below the circumorbital ring, the cheek is covered with strongly pectinated scales (*s.*). The depth of the

orbit in the fossil is evidently reduced by crushing, and the remains of the jaws are somewhat displaced; but the suspensorium must have been inclined a little forwards, with the articulation for the mandible beneath the middle of the eye. The jaws, so far as preserved, resemble those of *Hoplopteryx*, with the same conspicuously ornamented supramaxilla (*smx. 2*). The preoperculum (*pop.*) also resembles that of *Hoplopteryx*, with rounded angle and strongly pectinated hinder border. The well-preserved operculum (*op.*) shows traces of scales covering its antero-superior edge, but the greater part of it is exposed and ornamented with strong, short, rounded ridges, which are directed backwards. Two larger ridges beneath these extend from the point of suspension of the operculum to its great flattened posterior spine. The suboperculum (*sop.*) is relatively small, with ridged ornament directed downwards and backwards; while the interoperculum, exposed on the right side of the fossil, is large and similarly ornamented. The deep ceratohyal, shaped like that of *Hoplopteryx*, bears some large branchiostegal rays. The expanded upper lamina of the clavicle (*cl.*) and the scales are very strongly pectinated. The pectoral fin-rays (*pct.*) must have been delicate.

Horizon and Locality.—The matrix of the type and only known specimen in the Bowerbank Collection much resembles the marly chalk of the zone of *Holaster subglobosus*. It is labelled as having been obtained from Bromley, Kent.

Suborder APODES.

Family MURÆNIDÆ.

Genus **URENCHELYS**, A. S. Woodward.

Urenchelys, A. S. Woodward, Ann. Mag. Nat. Hist. [7], vol. v, 1900, p. 322.

Generic Characters.—Teeth small, bluntly conical, and arranged in numerous series. Slender branchiostegal rays not curving round the opercular apparatus. Vertebræ somewhat exceeding 100 in number, the hindermost bearing a pair of expanded hypural bones. Pectoral fins present; dorsal fin arising immediately behind the occiput and extending to the caudal fin, which has stouter rays and is very small but separate. Scales rudimentary.

Type Species.—*Urenchelys avus*, from the Upper Cretaceous of Sahel Alma, Mount Lebanon.

Remarks.—This genus is interesting as comprising the oldest known eels, which differ from all the Tertiary and existing eels in still retaining the caudal fin. Nearly complete specimens of two species have been obtained from the Upper Cretaceous of Mount Lebanon;[1] but only imperfect skulls have hitherto been dis-

[1] *Urenchelys avus* and *U. hakelensis*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, 1901, pp. 337—339, pl. xviii, figs. 1—3.

covered in the English Chalk. The latter fossils are provisionally ascribed to *Urenchelys* on account of their dentition and their general resemblance to the corresponding parts of the species from the Lebanon.

1. **Urenchelys anglicus**, A. S. Woodward. Plate IX, figs. 1—3.

1900. *Urenchelys anglicus*, A. S. Woodward, Ann. Mag. Nat. Hist. [7], vol. v, p. 321, pl. ix, fig. 1.
1901. *Urenchelys anglicus*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, p. 339.

Type.—Imperfect head from a Turonian zone; Willett Collection, Brighton Museum.

Specific Characters.—An imperfectly known and comparatively large species, the skull attaining a length of about 7 cm. Head much deeper in proportion to its length than in the type species.

Description of Specimens.—The type specimen is the only nearly complete head yet discovered, and is represented of the natural size from both sides in Pl. IX, figs. 1, 1 *a*. The information it affords is partly confirmed, partly supplemented by two other fragments evidently of the same species in the British Museum.

The cranium is shown to be very narrow and elongated, and its constituent bones are remarkably stout. Its roof in the parietal and frontal regions rises into a sharp median longitudinal ridge, and the occipital border is also raised. The parietal bones (*pa.*), as usual, meet in the middle line, but the shape of the suture between these and the frontals is uncertain. The squamosal bone on each side (Pl. IX, fig. 2, *sq.*) is traversed by a deep longitudinal slime-canal and extends in a slender pointed extremity nearly as far forwards as the anterior end of the frontals. The alisphenoidal ossification (*as.*) is seen below. There is a sharp post-orbital prominence (fig. 1, *sp.*), evidently formed by the cartilage-postfrontal or sphenotic. The precise shape of the ethmoidal rostral region (fig. 1, *eth.*) is not shown in either of the known specimens; but its total length seems to be about half that of the whole cranium. A displaced stout bar of bone on the right side of the type specimen above the maxilla is probably the parasphenoid (*pas.*).

The mandibular suspensorium is well displayed on each side of the type specimen. The upper articulation of the expanded hyomandibular (*hm.*) extends as far forwards as the sphenotic; and the articular end of the quadrate (*qu.*), for the support of the mandible, is directly beneath the same element. The pterygoid arcade (Pl. IX, fig. 3, *pt.*) is very delicate and toothless, and quite short, as usual in eels. The maxilla (fig. 1, *mx.*) is especially stout; and this element is displaced both on the left side of the type specimen (fig. 1 *a*, *mx.*) and in B. M. no. P. 4510 *a* (fig. 2, *mx.*) so as to expose its oral face, which is expanded, slightly concave, and marked with the bases of attachment of clustered small teeth. The premaxillæ

(fig. 1, *pmx.*) seem to be fused into a continuous mass with the mesethmoid and vomer. The bone thus formed is expanded and obtusely rounded in front, while its oral face is covered with a dense cluster of small, bluntly conical or hemispherical teeth. The mandible (*d.*) is deepest in the coronoid region, and tapers towards the symphysis with a characteristic curvature. The oral face of the dentary bone is somewhat expanded, and covered with a cluster of obtuse teeth resembling those of the rostrum but smaller.

The preoperculum (fig. 1, *pop.*) is well preserved in the type specimen, attached to the hinder border of the mandibular suspensorium. It is a rather stout bone, with a thickened straight anterior margin, and a small, semicircular posterior expansion. The operculum (fig. 1, *op.*) is a very small bone, constricted just below its thickened suspensory articulation and slightly expanded distally.

There are traces of vertebræ in the type specimen, but these are too imperfect for description.

Horizon and Localities.—Type specimen from zone of *Rhynchonella Cuvieri* or *Terebratulina gracilis*: Houghton, Sussex. Another specimen probably from same horizon near Dover.

Suborder ISOSPONDYLI.

Family Scopelidæ.

Genus **SARDINIOIDES,** W. von der Marck.

Sardinioides, W. von der Marck, Zeitschr. deutsch. geol. Ges., vol. x, 1858, p. 245.
Dermatoptychus, W. von der Marck, Palæontogr., vol. xv, 1868, p. 287.

Generic Characters.—Head large, and maximum depth of trunk at origin of dorsal fin. Cranial roof flattened, parietal bones meeting in middle line, and interorbital region wide; mandibular suspensorium nearly vertical; jaws moderately stout, and maxilla expanded behind; teeth minute and clustered; cheek scaly. Branchiostegal rays about 9 in number. Vertebræ between 30 and 40 in number, about half being caudal; the centra longitudinally striated and not longer than deep; ribs delicate. No fin-rays elongated, but two or three in front of median fins undivided and spinous. Pectoral fins delicate and small, inserted well above ventral border; pelvic fins larger and stouter, with about 7 rays, opposed to the dorsal fin, which is nearly median and comprises from 10 to 18 rays; anal fin behind dorsal, at least as deep as long, with about 10 rays; caudal fin slightly forked. Scales large and uniform, finely serrated on the hinder border, not deepened or thickened along the course of the lateral line.

Type Species.—*Sardinioides monasteri* (*Osmeroides monasterii*, Agassiz, Poiss. Foss., vol. v, pt. ii, 1839–44, p. 103, pl. lx *d*, fig. 3), from the Senonian of Westphalia.

Remarks.—The species of this genus are common in the Upper Cretaceous of Westphalia and Mount Lebanon, and the external aspect of one of the typical

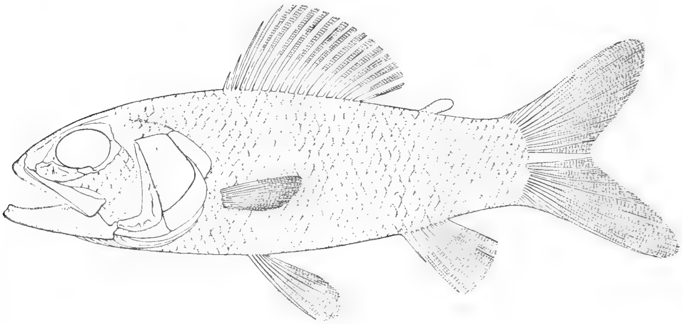

FIG. 6. *Sardinioides crassicaudus*, W. von der Marck; restoration, about one-half nat. size.—Senonian; Westphalia. The hinder extension of the suboperculum here represented is hypothetical, not yet observed.

forms is represented in the accompanying restoration, Text-fig. 6. The cranium of the genus has hitherto remained almost unknown; but the head of one Westphalian specimen in the British Museum (no. 43010), favourably exposed from above, seems to show a cranial roof identical with that of an English Chalk fossil, which other-

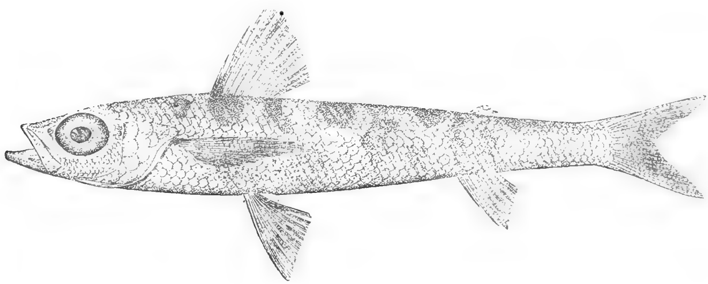

FIG. 7. *Chlorophthalmus chalybeius*, Goode; about nat. size.—Existing in moderately deep sea. After Goode and Bean.

wise displays several features in common with *Sardinioides.* The new specimen described below, if correctly identified, is thus of importance as affording the first clear view of the top of the cranium of *Sardinioides*, demonstrating its close resemblance to the corresponding part of the existing genus *Aulopus* (Pl. X, figs. 2, 2 *a*). The whole aspect of the head and opercular apparatus in the new *S. illustrans* is,

indeed, very suggestive of the latter genus; though *Aulopus* is proved to differ from the typical species of *Sardinioides* by its more numerous vertebræ (total 50), and by the elongation of some of its dorsal fin-rays. *Chlorophthalmus* (Text-fig. 7) is also an allied existing genus.

1. **Sardinioides illustrans,** sp. nov. Plate X, fig. 1.

1901. *Sardinioides*, sp. ind., A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, p. 242.

Type.—Imperfect fish from English Chalk; British Museum.

Specific Characters.—A robust species, attaining a length of about 20 cm. Imperfectly definable, but probably most closely resembling the type species, *S. monasteri*, with more feebly pectinated scales.

Description of Specimens.—This species is known only by the type specimen (Pl. X, fig. 1), and by an imperfect head in the British Museum. It is therefore not yet precisely definable.

As shown from above (Pl. X, fig. 1) the cranium is short and broad, with a flattened roof and wide interorbital region. The occipital border is straight, and the hinder face of the small supraoccipital bone bears a low median crest (*socc.*), which does not rise above the plane of the cranial roof. The thickened epiotic angles (*epo.*) project through the scales in the fossil. The short and broad parietal bones (*pa.*) meet in the median line, and that of the left is larger than that of the right side. The small squamosal and postfrontal bones must have partly covered the otic region, of which the roof slopes downwards and outwards on each side. The postfrontal (*ptf.*) is a narrow curved plate of bone, with its long axis directed at right angles to that of the cranium. The frontals (*fr.*) are remarkably broad throughout their length, and meet in a wavy median suture. There is a slight depression in their middle part, and they are traversed by a pair of very large longitudinal slime-canals. Each frontal is expanded over the hinder half of the orbit into an extensive supraorbital flange, which terminates suddenly in front and is continued by an antero-posteriorly elongated supraorbital bone (*spb.*). This region has been cut away in the second fossil in the British Museum (no. 49057). Beneath the truncated anterior end of the frontals, the short and broad mesethmoid (*eth.*) projects slightly forwards. Its front border is thickened and excavated by a slight re-entering angle, beneath the middle of which there is a little bony prominence. A pair of very small, long and narrow nasal bones (*na.*) can also be distinguished. All these bones, except the mesethmoid and nasals, bear a very delicate ornament of radiating wrinkles or rugæ.

The eye is shown to have been rather large and surrounded by a narrow ring of circumorbital plates. All these are imperfect in the type specimen, but the foremost plate of the ring is relatively large, and must have completely covered the

part of the cheek between the anterior half of the orbit and the maxilla. It shows traces of the usual slime-canal with radiating branches. Behind the circumorbital ring there are remains of large thin scales on the cheek.

The mandibular suspensorium is slightly inclined forwards, so that the quadrate articulation is beneath the hinder border of the orbit. The premaxilla (fig. 1 *a*, *pmx.*) is remarkably slender, completely excluding the maxilla from the gape; and the anterior half of its oral border is quite wide and tumid for the support of a cluster of minute teeth. The maxilla (*mx.*) is a stouter, laterally compressed bone, gradually expanding a little behind, and ornamented on its outer face with fine rugæ or partially subdivided ridges, of which the majority are directed obliquely to its long axis. The supramaxillæ (*smx.* 1, 2) extend along the hinder half of the maxilla, and resemble the two corresponding elements of the existing *Aulopus* (Pl. X, fig. 2). The mandible (*md.*) is a thin lamina much curved inwards below, and somewhat contracting and thickening to a truncated symphysis in front. Its oral border bears clustered minute teeth, and its outer face, where well preserved, is seen to be finely rugose.

The preoperculum (*pop.*) has a nearly vertical ascending limb, tapering to the upper end of the hyomandibular. Its angle is gently rounded and not much expanded, while its lower limb is comparatively short but wide. Its outer face seems to have been nearly smooth, and its hinder border is not serrated. The operculum (*op.*) and suboperculum (*sop.*) are rounded behind and below, and the latter element is relatively large, extending far upwards behind the operculum itself. Both bones are ornamented with a delicate rugosity, which tends towards a radiating arrangement on the operculum. Traces of long and slender branchiostegal rays are seen (*br.*).

The centra of the hinder abdominal vertebræ (fig. 1 *b*) are not longer than deep. They are much constricted, and strengthened by one median lateral ridge. The ribs are slender and articulate directly with the centra, which do not bear transverse processes.

The pectoral fins (*pct.*) comprise not less than 10 or 11 rays, of which only the bases are preserved in the fossil. The pelvic fins (*plv.*) are shown to have been far forwards, with rays much stouter than those of the pectorals. The dorsal fin (*d.*) also arises far forwards, and consists of very stout rays. It is crushed downwards to the left in the fossil, and its winged, dagger-shaped supports (*f.*) are exposed to the right. Only 10 dorsal fin-rays are clearly seen, though there were possibly more in the original fish; and their articulated distal ends are almost entirely wanting.

The scales are large and thin, and when their outer face is well preserved they are observed to be delicately pectinated at the hinder margin.

Horizon and Locality.—Unknown, but probably from one of the lower zones in the Burham district, Kent.

Genus **ACROGNATHUS**, Agassiz.

Acrognathus, L. Agassiz, Poiss. Foss., vol. v, pt. ii, 1844, p. 108.

Generic Characters.—Head large, with remarkably large orbits and narrow interorbital region; mandibular suspensorium nearly vertical; maxilla expanded behind; mandible delicate and dentary pointed at symphysis; teeth minute and clustered. Vertebræ between 30 and 40 in number. Pectoral fins delicate and small, inserted above ventral border; pelvic fins larger and stouter, with 7 or 8 rays; dorsal fin in the anterior half of the back, with 10 to 12 rays, none excessively elongated; anal fin small and remote; caudal fin forked. Scales large, thick, and uniform, not serrated on the hinder border, not deepened or thickened along the course of the lateral line, which is conspicuous.

Type Species.—*Acrognathus boops*, from the English Chalk.

Remarks.—The type species of this genus being still very imperfectly known, some characters mentioned in the foregoing diagnosis are derived from observations on a supposed allied species, *Acrognathus libanicus*, from the Upper Cretaceous of Mount Lebanon (Catal. Foss. Fishes B. M., pt. iv, 1901, p. 244).

1. **Acrognathus boops**, Agassiz. Plate X, fig. 3.

1844. *Acrognathus boops*, L. Agassiz, Poiss. Foss., vol. v, pt. ii, p. 108, pl. lx *a*, figs. 1—4.
1888. *Acrognathus boops*, A. S. Woodward, Proc. Geol. Assoc., vol. x, p. 323.
1901. *Acrognathus boops*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, p. 243.

Type.—Imperfect distorted fish, probably from one of the Turonian zones of the Chalk; British Museum.

Specific Characters.—The type species, attaining a length of about 12 cm. Length of head with opercular apparatus exceeding maximum depth, probably equalling about half length of trunk from pectoral arch to base of caudal fin. Dentary and angular bones of mandible marked with sharp radiating grooves. Scales quite smooth.

Description of Specimen.—Apart from an unimportant fragment, also in the British Museum, the type specimen is still the only known example of this species. It is an imperfectly preserved fish shortened by oblique distortion, its upper border being thrust forwards and a little downwards. It is shown of the natural size from the upper and right lateral aspects in Pl. X, figs. 3, 3 *a*. The fish must have been originally round-bodied and rather elongated; while the size of the orbit is probably not much exaggerated in the fossil.

The most striking features of the cranium are the shortness of the otic region and the narrowness of the interorbital region, due to the enormous size of the eye. The articular end of the quadrate is seen on the right side of the fossil (fig. 3 *a*, *qu.*), and the mandibular suspensorium is proved to have been nearly vertical. The maxilla (*mx.*) is clearly expanded behind. Each mandibular ramus is a thin lamina, contracting to a point at the symphysis, as well represented in Agassiz's fig. 4, *loc. cit.* The dentary is conspicuously ornamented with fine grooves radiating from the symphysis, and its oral border bears clustered minute teeth. The angular is similarly ornamented. The opercular apparatus seems to have been rather narrow and nearly smooth; and on the left side of the fossil there are traces of very long and slender branchiostegal rays.

The base of the left pectoral fin is preserved (fig. 3, *pct.*), comprising 12 delicate rays, inserted distinctly above the ventral border. Traces of the much stouter rays of the pelvic fins are also seen (fig. 3 *a*, *plv.*), situated far forwards. The anteriorly placed dorsal fin (*d.*) is represented only by the bases of 11 rays, most of them rather stout, exposed in cross-section. The remote and small anal fin (*a.*) is still more fragmentary.

The scales in the type specimen are displaced and crushed over each other, so that their exposed area is not so extensive as it must have been originally. They are large and moderately thick, and apparently quite smooth. When their hinder border is well preserved, it appears to form a gentle curve without any serrations. There is a small triangular eminence on each scale traversed by the lateral line.

Horizon and Localities.—Probably from a Turonian zone: neighbourhood of Lewes. Undetermined horizon at Shalford, near Guildford.

Family ENCHODONTIDÆ.

A family of Cretaceous fishes closely related to the existing Scopelidæ, Odontostomidæ (Text-fig. 8), and Alepisauridæ, but distinguished from all of these by having the margin of the upper jaw formed partly by the maxilla. The teeth are firmly fused with the supporting bone, not implanted in sockets.

Genus **APATEODUS**, A. S. Woodward.

Apateodus, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, 1901, p. 258.

Generic Characters.—Head elongate and acutely pointed, and the flattened cranial roof destitute of ornamentation. Premaxilla and maxilla extremely delicate, the former being a vertical lamina with a uniform series of very small teeth;

palatine thickened but antero-posteriorly elongated and pointed in front, with two much-enlarged, well-spaced teeth, which are laterally compressed; ectopterygoid less stout, with a close series of smaller but similar laterally compressed teeth; mandible constricted at the symphysis and without external ornament, the dentary bearing a single series of laterally compressed teeth, of which those in the middle are the largest.

Type Species.—Apateodus glyphodus (A. S. Woodward, *tom. cit.*, p. 258, pl. xiii, figs. 3—5), from the English Gault.

Remarks.—This genus is known only by the head, of which the upper jaw was wrongly interpreted in the original diagnosis of 1901. The relatively small premaxilla and maxilla were at that time overlooked, while the palato-pterygoid arcade was described as the premaxilla. The true premaxilla, bearing a regular series of

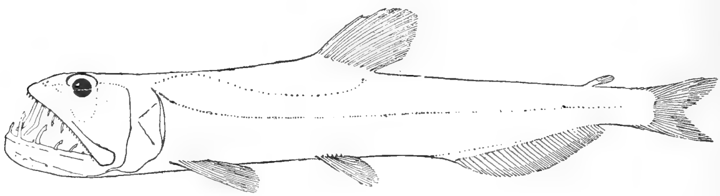

FIG. 8. *Odontostomus hyalinus*, Cocco; reduced from nat. size.—A representative of the Odontostomidæ existing in Mediterranean. After Günther.

very small teeth, is best displayed in a fine skull from the Danian of Maastricht in the Brussels Museum (L. Dollo).

1. **Apateodus striatus**, A. S. Woodward. Plate XI, figs. 1—7; Text-figure 9.

(?) 1837–44. *Saurocephalus striatus*, L. Agassiz, Poiss. Foss., vol. v, pt. i, p. 102, pl. xxv *c*, figs. 17—20.

1850. *Saurocephalus striatus*, F. Dixon, Geol. Sussex, p. 375, pl. xxxv, fig. 5.

1901. *Apateodus striatus*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, p. 260, pl. xiii, fig. 6, pl. xiv.

Type.—Small head from a Turonian zone; British Museum.

Specific Characters.—A species known only by the head, with mandible probably attaining a length of about 15 cm. The anterior enlarged palatine tooth about two thirds as long as the posterior tooth, and the length of the latter equalling the interspace between the two teeth, also about half the length of the part of the palatine in front of its insertion. Maximum depth of mandible equalling about one fifth of its length; dentition occupying half its length, with two relatively large teeth of about equal size in the middle of the series, with small broad teeth behind,

and still smaller recurved teeth in front. Large teeth much laterally compressed, and marked with very fine vertical striations in the basal portion.

Description of Specimens.—The small fragment of jaw in the Mantell Collection, described by Agassiz under the name of *Saurocephalus striatus*, is probably part of the ectopterygoïd of this species, but is insufficient for exact determination. A small head in the Capron Collection (Pl. XI, figs. 1, 1 *a*, 1 *b*) was therefore chosen for the type specimen when the species was first defined.

The long and narrow, acutely pointed cranium is shown in the type specimen, and more imperfectly in a smaller specimen described in the British Museum Catalogue (pt. iv, p. 262, pl. xiv, fig. 2). It is remarkable for the lack of a tubercular ornament on the radiating ridges of the frontal and parietal bones. The

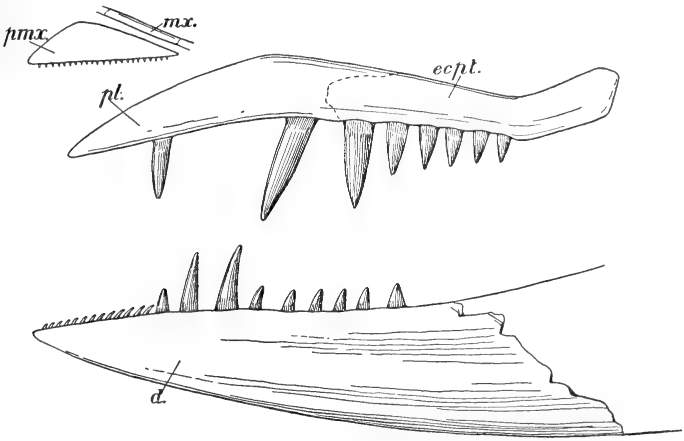

FIG. 9. *Apateodus striatus*, A. S. Woodward; diagram of jaws, left side, outer aspect.—English Chalk. *d.*, dentary; *ecpt.*, ectopterygoid; *mx.*, fragment of maxilla (remainder unsatisfactorily known); *pl.*, palatine; *pmx.*, premaxilla.

supraoccipital (Pl. XI, fig. 1 *b*, *socc.*) enters extensively into the cranial roof, though the overlapping frontals may perhaps be partly removed in the type specimen. The parietal (*pa.*) is a small triangular bone completing the postero-lateral angle of the flattened part of the cranial roof between the projecting otic regions. The very large frontals (*fr.*) extend on each side into a considerable supraorbital flange, and the few ridges on each of these bones radiate from a point just above and within the middle of the flange. The frontal region in the type specimen is broken across at the anterior border of the orbit, and the attenuated rostral region has not been satisfactorily observed. The mesethmoid, however, must have been very little exposed. The sclerotic (fig. 2, *scl.*) is well ossified.

The mandibular suspensorium is vertical, so that the quadrate articulation is

observed beneath the occiput. The quadrate in the type specimen (fig. 1, *qu.*) is clearly excavated for the reception of a symplectic (*sy.*). The stout upper tooth-bearing bone is proved to be the palato-pterygoid arcade by the original of fig. 2, where its hinder end is distinctly continuous with the metapterygoid region; and part of the latter is again shown in the fragment represented in fig. 6. This fossil comprises the hinder end of a slender ectopterygoid (*ecpt.*) with characteristic teeth, a fragment of the hyomandibular (*hm.*), and part of the laminar metapterygoid (*mpt.*), which is nearly completely preserved in a smaller specimen (fig. 7). Part of a larger ectopterygoid, with some teeth, is also shown in fig. 5. All these teeth are lanceolate and much laterally compressed, with two sharp, smooth edges, and the outer and inner face ornamented by very delicate vertical striations, which are most conspicuous at the base. The ectopterygoid appears to have extended about half the length of the jaw, overlapping the palatine at the deepest part of the arcade, where it is slightly bent; though the suture has only been imperfectly observed in one specimen (fig. 3). The palatine is relatively very stout and nearly quadrangular in transverse section, gradually tapering to a point as it slopes downwards in front. Its flattened inner face (fig. 3, *pl.*) is apposed for a long extent to the slender rostrum; and its hinder end is distinctly shown to be hollow. Its flattened oral face has a sharp outer margin, which deepens behind into a thin bounding wall. It bears two large teeth, of which only the bases, fused with the bone, are indicated in fig. 3, but of which the complete crowns are represented in fig. 4. These teeth are finely striated at the base, but their laterally compressed crowns, each with two sharp edges, are almost or quite smooth. Their relative proportions are noted in the specific diagnosis. Between them there are sometimes traces of two or three very small teeth on the outer edge of the bone. The premaxilla and maxilla are relatively very small and delicate, and scarcely known. There are traces of them on the left side of the type specimen (fig. 1 *a*), where the premaxilla (*pmx.*) seems to have been an elongate-triangular lamina of bone, while the underlapped anterior end of the maxilla (*mx.*) is rod-shaped. The rod-shaped bone represented by fragments outside and below the palato-pterygoid in the original of fig. 3, *mx.*, may also perhaps be the maxilla. No teeth are seen on any of these remains. An imperfect mandible in the Willett Collection (no. 88), Brighton Museum, has already been figured by Dixon, *op. cit.* The mandible is much fractured on both sides of the type specimen, and its hinder part is lacking in the original of fig. 2. Its principal characters, however, are shown by these fossils. It is gently curved upwards at either end; its lower portion bends considerably inwards; its hinder end is deepest and sharply truncated just in front of the small articular prominence; while its symphysial end is bluntly pointed. Its outer face is nearly smooth, only marked by a few longitudinal grooves. The dentary (*d.*) extends backwards almost to the end of the jaw, covering the articulo-angular (*ag.*) so that very little of the latter element is exposed in outer view

(except when the dentary is partly broken away, as in fig. 1). There is only a single row of teeth confined to the anterior half of the dentary, where they are fused with the outer margin. The foremost teeth are very small and recurved, in close series, gradually increasing a little in size behind; then follows a somewhat larger tooth, not recurved but much laterally compressed and ornamented with delicate vertical striations; next are the two largest teeth, similar in character to the last and biting between the two large teeth of the palatine. Behind these, again, are six or seven well-spaced small lanceolate teeth, rather irregular in size, with the hindermost tooth the largest. A complete restored sketch of the palato-pterygoid and mandibular dentition is given in Text-fig. 9 p. 39.

The cheek must have been completely covered with thin plates, which are quite smooth and only marked by the passage of the slime-canal (B. M. nos. P. 4512, P. 9015). The anterior margin of the preoperculum (imperfectly seen in fig. 1) is thickened and rounded, while the operculum seems to have been smooth.

Some of the vertebral centra are strengthened with lateral longitudinal ridges (B. M. no. 49067), and the foremost centrum is very short and deep (B. M. no. P. 5647).

Horizon and Localities.—Zones of *Holaster subglobosus* to *Terebratulina gracilis:* neighbourhood of Lewes, Sussex; neighbourhood of Burham, Kent. Zone of *Holaster subglobosus:* Merstham, Surrey; Cherry Hinton, Cambridgeshire. Probably zone of *Terebratulina gracilis:* Cuxton, Kent.

2. **Apateodus lanceolatus,** A. S. Woodward. Plate XI, fig. 8.

1901. *Apateodus lanceolatus,* A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, p. 264, pl. xiii, fig. 7.

Type.—Palatine bone from zone of *Holaster subglobosus;* British Museum.

Specific Characters.—Palatine bone comparatively short, with the two enlarged teeth inclined slightly forwards, about equal in size, or the anterior slightly the larger, and the interspace between them much less than their height.

Description of Specimens.—Various fragments of jaws of *Apateodus* are known from the Grey Chalk, but the only fossil capable of specific determination hitherto observed is the specimen shown of the natural size, outer aspect, in Pl. XI, fig. 8. This is a right palatine bone, lacking the anterior pointed end and crossed by an oblique fracture behind. It is shorter than in the other known species, and the enlarged teeth are of peculiar proportions, as noted in the specific diagnosis. The anterior end of the ectopterygoid (*ecpt.*) clearly overlaps the palatine behind, and the two posterior teeth preserved in the fossil are probably borne by this element. All the teeth exhibit the characteristic striation at the base.

Horizon and Locality.—Zone of *Holaster subglobosus:* Dover.

Genus **PRIONOLEPIS**, Egerton.

Prionolepis, Egerton, in F. Dixon, Geol. Sussex, 1850, p. 368.
Aspidopleurus, Pictet and Humbert, Nouv. Rech. Poiss. Foss. Mt. Liban, 1866, p. 107.
Apateopholis, A. S. Woodward, Proc. Zool. Soc., 1890 (1891), p. 634.

Generic Characters.—Head and trunk elongate, much laterally compressed. Head acutely pointed, and the cranial roof exhibiting a median longitudinal depression, its lateral and occipital margins ornamented with ridges and tubercles of ganoine. The conical teeth irregular in size, largest in the anterior part of the mandible, small and obtuse behind. Operculum strengthened on the inner side by a ridge extending horizontally backwards from the point of suspension; preoperculum narrow and deep, its lower end bearing a slender, posteriorly directed spine. Vertebræ about 45 in number, the centra at least as long as deep and constricted mesially. Paired fins large, the pectorals not much larger than the pelvic pair, which are opposed to the hinder part of the dorsal fin; dorsal fin nearly median, comprising from 16 to 20 rays; anal fin with slightly fewer rays than the dorsal, and much smaller; caudal fin forked, with curved fulcral rays and stout, articulated, undivided rays at its base both above and below. Dermal scutes in one deepened series on the flank, each scute overlapping its fellow and traversed above by the course of the lateral line.

Type Species.—*Prionolepis angustus*, from the English Chalk.

Remarks.—This genus is represented by nearly complete fishes from the Upper Cretaceous of Mount Lebanon originally made known under the names of *Aspidopleurus* and *Apateopholis*. Technical descriptions of them are published in the Catal. Foss. Fishes B. M., pt. iv, 1901, pp. 229—233.

Prionolepis angustus, Egerton. Plate IX, figs. 4—9.

1850. *Prionolepis angustus*, Egerton, in Dixon, Geol. Sussex, p. 368, pl. xxxii*, fig. 3.
1888. *Prionolepis angustus*, A. S. Woodward, Proc. Geol. Assoc., vol. x, p. 306.
1901. *Prionolepis angustus*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, p. 230.

Type.—Dermal scutes from zone of *Holaster subglobosus*; British Museum.

Specific Characters.—Known only by the scutes of the flank. The largest scutes about seven times as deep as broad, and the forwardly directed portion above the lateral line comparatively short; the hinder margin very regularly, closely, and deeply pectinated; the anterior portion either smooth or marked with very feeble vertical rugæ, except above the lateral line, where these rugæ are conspicuous.

Description of Specimens.—The type specimen in the Dixon Collection comprises an imperfect mass of scutes, of which those best preserved are still arranged in regular series and exposed from the inner aspect. The latter are shown upside down in Dixon's original figure; and one of the associated fragments displaying the outer face is similarly inverted. The only other specimens hitherto discovered are scattered scutes.

All these scutes are very deep and narrow, and crossed near their upper end by the canal of the lateral line. When complete each scute is six or seven times as deep as broad; and it exhibits a slight sigmoidal curvature, the sharpest bend being forwards above the lateral line. Each end contracts to a blunt point, the posterior border converging to the anterior border at the upper extremity (Pl. IX, figs. 5, 6, 9), while the reverse convergence occurs at the lower extremity (Dixon's figure and Pl. IX, figs. 7, 8). The anterior border of the scute is bevelled to a very slight extent for the overlapping of the preceding scute; and there is a little vertical ridge on the smooth inner face marking the hinder limit of the overlapping facette at least in the lower part of the scute (fig. 4, *r.*). A broad band at the hinder margin of the outer face is covered with a regular series of strong and parallel pectinations, which are inclined somewhat obliquely downwards and backwards and end in sharp points. The piercing canal of the lateral line (figs. 5, 6, 9, *l.*) forms a prominent smooth ridge, which is rounded and widest in front but tapers to an acute spine behind. Below this ridge the anterior half of the outer face of the scute is almost or quite smooth, with not more than feeble traces of vertically disposed rugæ. Above the lateral line the outer face behind the pectinations is marked with one or more sharp vertical ridges.

Horizons and Localities.—Zone of *Holaster subglobosus:* Burwell and Cherry Hinton, Cambridgeshire; Dover; Clayton, Sussex; Calne, Wiltshire. Zone of *Holaster planus:* Swaffham, Norfolk.

Fragments of scutes of *Prionolepis*, much like those of the type species but completely covered with a conspicuous rugose ornament, are also known from the Chalk of Dorking, Surrey (Capron Collection, B. M. no. 49776).

Genus **CIMOLICHTHYS**, Leidy.

Cimolichthys, J. Leidy, Trans. Amer. Phil. Soc., vol. xi, 1857, p. 95.
(?) *Plinthophorus*, A. Günther, Geol. Mag., vol. i, 1864, p. 115.
Empo, E. D. Cope, Proc. Amer. Phil. Soc., vol. xii, 1872, p. 347.

Generic Characters.—Head elongate and acutely pointed; trunk elongate-fusiform. Cranial roof exhibiting a deep median longitudinal depression, its lateral and occipital margins ornamented, like some of the other external bones,

with ridges and tubercles of ganoine. Premaxilla in the form of a vertical lamina, which is either toothless or with a series of minute teeth; maxilla long and styliform, similarly either toothless or with minute teeth where it enters the oral margin; ectopterygoid bearing a single spaced series of acute, laterally compressed teeth, which are largest in front and sometimes exhibit a single posterior barb towards their apex; palatine with a double longitudinal series of teeth, the largest behind; dentary thin, but so bent that it has a wide horizontal extent, with a close series of minute teeth on its extreme outer margin, another close series of larger teeth within this, and a third inner series of relatively large recurved teeth, well spaced, sometimes barbed at the apex. Operculum strengthened on the inner side by a ridge extending horizontally backwards from the point of suspension. Vertebræ from 50 to 60 in number, about half being caudal; the centra at least as long as deep, much constricted, and marked with fine irregular longitudinal ridges. A series of large dermal scutes along the dorsal ridge between the occiput and the dorsal fin; smaller scutes along the course of the lateral line.

Type Species.—Cimolichthys lewesiensis, from the English Chalk.

Remarks.—The barbed teeth of this genus (Pl. XII, figs. 3, 4) were originally referred by Agassiz, in error, to the Cretaceous *Saurodon leanus*, Hays, which is quite a distinct fish found in the Greensand of New Jersey, U.S.A. They have subsequently received other names, and have even been compared with the barbed teeth of the Scombroid *Anenchelum* or *Lepidopus*. The arrangement of the scutes on the trunk is not completely determined; but an American fossil provisionally ascribed to the so-called *Empo*, exhibits three longitudinal series of rhombic scutes on the flank of the abdominal region. Their " apices are directed forwards, and the surface has a reticulate sculpture. In another species they appear to be smooth" (*Cope*). It is thus very probable that the trunk named *Plinthophorus* really belongs to *Cimolichthys lewesiensis.*

1. **Cimolichthys lewesiensis**, Leidy. Plate IX, figs. 10—14; Plate XII; Text-figure 10.

1835–44. *Saurodon leanus*, L. Agassiz, Poiss. Foss., Feuill. p. 55, and vol. v, pt. i, p. 102, pl. xxv *c*, figs. 30, 31 (*errore*).
1850. *Saurodon leanus*, F. Dixon, Geol. Sussex, p. 373, pl. xxx, figs. 28, 29; pl. xxxii*, fig. 10 (*errore*).
1857. *Cimolichthys levesiensis*, J. Leidy, Trans. Amer. Phil. Soc., vol. xi, p. 95.
(?) 1864. *Plinthophorus robustus*, A. Günther, Geol. Mag., vol. i, p. 115, pl. vi.
1878. *Cimolichthys levesiensis*, E. T. Newton, Quart. Journ. Geol. Soc., vol. xxxiv, p. 795.
1888. *Cimolichthys levesiensis*, A. S. Woodward, Proc. Geol. Assoc., vol. x, p. 316.
1901. *Cimolichthys lewesiensis*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, p. 221.

Type.—Imperfect ectopterygoid with teeth, from one of the Turonian zones; British Museum.

Specific Characters.—Maximum width of cranium slightly exceeding one third of its length, and premaxilla ornamented with radiating tuberculated ridges; length of mandible about five times as great as its maximum depth. Four ectopterygoid teeth, of which the two foremost are moderately slender and slightly barbed; inner and outer palatine teeth nearly equal in size, with about 10 sockets in front of the enlarged postero-internal tooth; some of the palatine teeth slightly barbed; six recurved teeth, scarcely barbed, in the inner mandibular series, the third and largest situated within the anterior half of the dentary.

Description of Specimens.—The type specimen in the Mantell Collection is the greater part of the left ectopterygoid exposed from within and displaying two of the barbed teeth, as shown in the original figure by Agassiz. Another specimen in

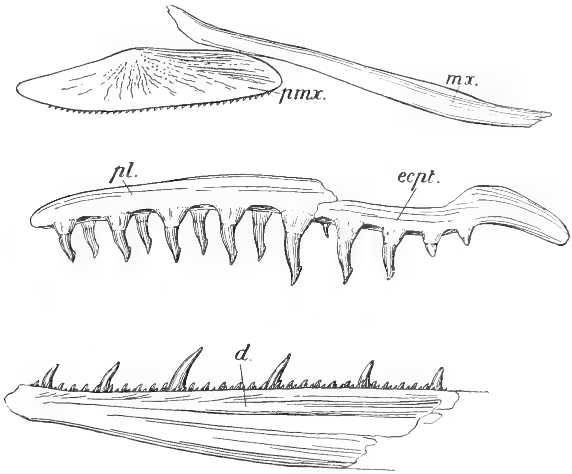

FIG. 10. *Cimolichthys lewesiensis*, Leidy; diagram of jaws; the premaxilla (*pmx.*), maxilla (*mx.*), and dentary (*d.*) of left side, outer aspect; the palatine (*pl.*) and ectopterygoid (*ecpt.*) of right side, inner aspect.—English Chalk.

the Willett Collection, Brighton Museum, also shows the characteristic ectopterygoid in association with the mandible and other remains, and is figured by Dixon, *op. cit.*, pl. xxxii*, fig. 10. All the other most important known specimens are contained in the various collections now brought together in the British Museum.

The general proportions of the skull are shown by the two specimens represented from the upper and lateral aspects in Pl. XII, figs. 1, 1 *a*, 2. The occipital face is sharply bent in the middle, so that it is observed to be excavated by a re-entering angle when viewed from above; but it does not project backwards beyond the exposed cranial roof. The small supraoccipital bears a large posterior crest (*socc.*), which does not rise above the plane of the flattened cranial roof; and its

anterior portion just enters the roof, separating the two parietals (*pa.*), which form a remarkably narrow border, and are traversed by a large transverse slime-canal (seen in B. M. no. P. 5491). The frontals (*fr.*) form nearly the whole of the cranial roof, expanding to their widest point above the back of the eye and gradually tapering forwards. Their middle portion is smooth and depressed into a shallow fossa; while their lateral half is strongly ornamented by finely tuberculated, radiating ridges, as shown in fig. 1. The long and narrow otic region does not project outwards beyond the widest part of the frontals. A pair of much-elongated, smooth nasal bones (*na.*) are indicated by remains on the pointed rostrum.

The eye is only of moderate size, and the sclerotic is ossified (fig. 1 *a*, *scl.*). A narrow ring of circumorbital plates borders the orbit at least behind and below (B. M. no. P. 1810 *a*), each plate being traversed by the large slime-canal and ornamented with fine tuberculations which are arranged in radiating lines. The greater part of the cheek must have been naked.

The mandibular suspensorium is vertical, so that the quadrate articulation is beneath the occipital border. The hyomandibular (Pl. XII, fig. 2, *hm.*) is much expanded at its upper end to articulate with the antero-posteriorly elongated pterotic region; and it seems to taper below where it must have met the symplectic. It bears a large laminar vertical crest on the upper part of its outer face, which is crushed backwards upon the preoperculum in the fossils (*cr.*). The metapterygoid (*mpt.*) is rather large and thin, almost triangular in shape, and strengthened by a slight ridge which extends upwards and forwards from its postero-inferior angle. The fan-shaped quadrate (*qu.*) is much longer than deep, and also rather thin. The ectopterygoid (Pl. IX, fig. 10) is a stout elongated bone, thickened for the support of a powerful dentition. It bears a single series of four well-spaced teeth, which decrease in size backwards. Each tooth is hollow and has a large tumid base, firmly fused with the bone; while the crown is slightly curved backwards and laterally compressed, with its anterior edge and at least part of its posterior edge quite sharp, and the faces ornamented by fine longitudinal striations. Each successional tooth arises in a shallow socket immediately in front of or behind the tooth about to be replaced; so that the actual position of the teeth differs in different specimens, while a nearly replaced tooth and its successor are often seen side by side. The two foremost ectopterygoid teeth exhibit one posterior barb, and their sharp edge, which does not extend below the barb behind, is very delicately crenulated. The two hinder teeth are comparatively small and very short and stout, without any barb. In the specimen figured, Pl. IX, fig. 10, the hindermost tooth is accompanied by its adjoining successor. The same fossil shows the anterior limit of the ectopterygoid, where its thickened end is suturally united with the equally stout palatine (*pl.*). Other specimens indicate that its upper margin is thin where it meets the laminar entopterygoid, which bears a cluster of minute teeth on its oral face (B. M. no. P. 5491). The palatine is a

depressed bar of bone, about as long as the ectopterygoid but wider than the latter and tapering in front, as well observed from above (Pl. IX, fig. 12 *a*). It bears two longitudinal rows of teeth, which resemble those of the ectopterygoid in form and mode of succession. The largest tooth is the hindermost member of the inner series, which is imperfect and accompanied by part of its successor in the original of Pl. IX, fig. 10. This tooth is shown by other specimens to have been slightly barbed behind (Pl. IX, fig. 12, *p.*). In advance of it there are about ten shallow tooth-sockets in close series, each ovoid in shape with the longer axis obliquely directed (Pl. IX, fig. 11). The teeth occupying these sockets are scarcely known, but there would probably be four or five simultaneously in function. Two of them near the anterior end of the bone in B. M. no. P. 5491 are slightly barbed posteriorly close to the apex. The teeth of the outer palatine series are also imperfectly known; but the incomplete specimen represented from the oral aspect in Pl. IX, fig. 11, shows that they must have been about as numerous as those of the inner series and all inclined a little outwards, without any enlarged hindermost tooth. The premaxilla (Pl. XII, figs. 1 *a*, 2, *pmx.*) is an antero-posteriorly elongated thin lamina of bone, tapering at both ends. Its total length is more than four times as great as its maximum depth; and its outer face, when well preserved (Pl. XII, fig. 1 *a*, *pmx.*), is ornamented by rows of tubercles and discontinuous ridges, which radiate from a point near the upper border at the deepest part of the bone. Both the specimens figured are somewhat flaked and imperfect, and do not display the oral margin. When this is preserved, it is seen to bear a single regular series of very small, slender, conical teeth (B. M. no. P. 1810 *a*). The maxilla (Pl. XII, figs. 1 *a*, 2, *mx.*) is a long and rather stout bar of bone, without any external ornament but displaying its fibrous texture. The premaxilla extends beneath its anterior third, but the hinder two thirds seem to enter the gape of the mouth. There are no traces of teeth in the known specimens. The hinder end of the bone is overlapped by a very small supramaxilla (Pl. XII, fig. 1 *a*, *smx.*), which is antero-posteriorly elongated and ornamented with longitudinal tuberculated ridges. The mandible is imperfectly represented in Pl. XII, fig. 1 *a*, where its length is shown to be about five times as great as its maximum depth. It tapers very rapidly to the constricted symphysis. The outer face of the dentary (*d.*) is marked only by a few delicate smooth ridges, which radiate from the symphysis and are confined to a narrow band on the oral border and to the lower part of the bone. The articulo-angular element (*ag.*) is antero-posteriorly elongated, and marked on its outer face by a few smooth longitudinal ridges which extend forwards from a point just beneath the mandibular articulation. The oral border of the dentary bears three series of teeth, all of which are hollow, conical, and recurved, and firmly fixed at the base in a very shallow socket. The extreme outer margin is furnished with a single close series of quite minute teeth, of which only the sockets remain in the original of Pl. IX, fig. 14, but of which a few crowns are seen in

fig. 13, III. Immediately within this series there is another close row of somewhat larger teeth, partly shown in both of the figures cited (II). Further inwards there occurs a widely spaced series of six large teeth (I), of which the foremost at the symphysis is broken away in both of the specimens figured. These large teeth are smoother than those of the palato-pterygoid arcade, and only compressed to a sharp edge quite at the apex, where the barb is scarcely if at all observable. Their mode of replacement is the same as that already described, and the fourth tooth in the original of fig. 13 is accompanied by its successor. The third tooth from the symphysis is usually the largest member of the series. The general aspect of the jaws is diagrammatically represented in Text-fig. 10, p. 45. The ceratohyal (Pl. XII, fig. 2 *a*) is much elongated and laterally compressed.

The opercular apparatus (Pl. XII, fig. 1 *a*) is scarcely known. The preoperculum (*pop.*) is deep and narrow, almost without a lower limb, but slightly pectinated at the lower border. The operculum (*op.*) is thin and ornamented, at least in its anterior portion, with sparse rows of small tubercles.

The post-temporal (Pl. XII, fig. 1, *ptt.*) is an elongate-triangular lamina of bone, with its anterior apex impinging on the supraoccipital. On its outer face some short, fine, tuberculated ridges radiate from its truncated postero-external angle.

Trunk named Plinthophorus robustus.—The trunk of *Cimolichthys lewesiensis* has not hitherto been found in association with the head; but the specimen shown of one half the natural size in Pl. XII, fig. 5, is probably referable to this species. It has already been described by Dr. Günther, *loc. cit.*, 1864, under the name of *Plinthophorus robustus.* The fossil is a little distorted in front and below, but the trunk is shown to have been elongate-fusiform, with the abdominal region longer than the caudal region. A few of the anterior vertebræ are lacking, but the total number in the column must have been originally about 60. The vertebral centra are slightly longer than deep, each much constricted in the middle and strengthened by a few longitudinal ridges. The ribs are slender and not much arched, evidently not reaching the ventral border. The neural spines in the abdominal region are also slender; but those in the caudal region, like the opposite hæmals, seem to be somewhat stouter, rather short and curved backwards, until they reach the caudal fin, where they are quite recumbent and thickened. The pectoral fins (*pct.*) are long and narrow, comprising 12 rays, of which the unjointed bases are preserved. The pelvic fins (*plv.*), which are still more imperfect in the fossil, seem to have been nearly as large as the pectorals, with 10 or 11 rays. They have a broad base supported by a pair of much-expanded, laminar pelvic bones. The dorsal fin (*do.*) is completely within the anterior half of the trunk, terminating behind opposite the insertion of the pelvic pair. It comprises at least 14, perhaps 16 rays, of which the foremost are much the longest and stoutest. The anal fin is remote, and must have been much smaller than the dorsal, but it is only represented

by fragments (*a.*). The caudal fin (*c.*) seems to have been forked, but only the bases of its stout rays remain. There are no traces of scales, but the body is shown to have borne longitudinal series of bony scutes. In front of the dorsal fin, there is a chain of four or five large ovoid or rhomboidal scutes exposed from the inner aspect. These (I) are very slightly saddle-shaped, and only overlap to quite a small degree. Where their substance is broken away, the impression of an external ornament of radiating, tuberculated ridges is observable. They have, indeed, the appearance of median dorsal ridge-scutes, like those occurring in the American species of *Cimolichthys* (see 'Catal. Foss. Fishes B. M.,' pt. iv, 1901, p. 224, fig. 8). Immediately below the dorsal fin there are the partially displaced remains of a series of small scutes, more distinctly rhomboidal in shape, exposed from the outer aspect (II). Remains of other scutes of this series are also seen scattered at various points behind the dorsal fin. The exposed portion of each of these scutes is longer than deep, with a sharp median longitudinal ridge, from which finer ridges and rows of tubercles radiate to the periphery. The series may have been disposed along the course of the lateral line, but none of the scutes display any distinct traces of the slime-canal. Another paired series of scutes (III) is well seen at the distorted ventral border of the trunk between the paired fins, with traces of its continuation further backwards. These scutes are exposed from the outer face on the right, but from the inner face on the left side of the fish; and they are very similar to those of series no. II just described. All of them are imperfect, but one marked *x* in Pl. XII, fig. 5, is more satisfactorily preserved than the majority, and is represented of twice the natural size in fig. 5 *a*. The anterior, smooth, overlapped portion is narrow and extended; and some of the radiating ridges on the exposed portion are more prominent than the others. The scute at the base of the pelvic fin is much enlarged, with the hinder margin notched to adapt it to its situation.

Horizons and Localities.—Zones of *Holaster subglobosus* to *Terebratulina gracilis:* neighbourhood of Lewes, Sussex; Burham, Kent. Zone of *Holaster subglobosus:* Halling, Folkestone, and Dover, Kent; Glynde, Sussex. Zone of *Terebratulina gracilis:* Warlingham, Surrey. Zone of *Micraster coranguinum:* South Croydon, Surrey; Thanet, Kent. Also teeth in higher zones probably of this species.

Genus **HALEC**, Agassiz.

Halec, L. Agassiz, Verhandl. Ges. vaterl. Mus. Böhmen, 1834, p. 67.
Pomognathus, F. Dixon, Geol. Sussex, 1850, p. 367.
Archæogadus, W. von der Marck, Palæontogr., vol. xv, 1868, p. 291.
Phylactocephalus, J. W. Davis, Trans. Roy. Dublin Soc. [2], vol. iii, 1887, p. 605.

Generic Characters. — Trunk rather deeply fusiform, both this and the head laterally compressed. Cranial roof exhibiting a median longitudinal depression, its lateral and occipital margins ornamented, like the other external bones, with ridges and tubercles of ganoine. Mandible a little prominent, with several rows of recurved conical teeth, irregular in size and arrangement; premaxilla long and slender, with one or more rows of minute teeth; maxilla long and slender, underlapped by the premaxilla for the greater part of its length, but entering the gape behind, where it bears a spaced series of relatively large conical teeth pointing forwards; a conspicuous supramaxilla present; the comparatively stout palatine and ectopterygoid bones bearing a close series of acute, laterally compressed teeth, which are largest in the middle and diminish towards each extremity; no teeth barbed. Preoperculum very narrow and deep, with a conspicuous posteriorly directed spine at its lower end; operculum strengthened on the inner side by a ridge extending almost horizontally backwards to its postero-inferior angle; branchiostegal rays about 15 in number. Vertebræ from 35 to 45 in number, the centra at least as long as deep, much constricted mesially and somewhat strengthened with small longitudinal ridges. Fin-rays robust and all articulated, mostly also subdivided distally; no fin-rays excessively elongated. Paired fins large, the pelvic pair not much smaller than the pectorals; the short dorsal fin within the anterior half of the trunk; anal fin relatively small and remote; caudal fin deeply forked. Enlarged dermal scutes restricted to the end of the tail.

Type Species.—*Halec sternbergi* (L. Agassiz, 'Poiss. Foss.,' vol. v, pt. ii, 1844, p. 123, pl. lxiii), from the Turonian of Bohemia.

Remarks.—The fish from the English Chalk commonly known as *Pomognathus*, is proved by direct comparison of specimens to be generically identical with *Halec*, which was inadequately described by Agassiz from the Bohemian Chalk. It also agrees in the characters of the head and fins with the so-called *Phylactocephalus*, from the Upper Cretaceous of Mount Lebanon and Dalmatia, which is only distinguished by its smaller number of vertebræ (35) and by its covering of minute scales. The latter difference, however, may be more apparent than real, considering the nature of the matrix in which the English fossils occur. *Archæogadus guestphalicus*, from the Plänerkalk of Dortmund, certainly belongs to *Halec*, as shown by the type specimen in the Academy of Münster, Westphalia.

1. **Halec eupterygius** (Dixon). Plate XIII; Text-figure 11.

1837. *Osmeroides lewesiensis*, L. Agassiz, Poiss. Foss., vol. v, pl. lx *b*, figs. 3, 4 (*errore*).
(?) 1844. *Osmeroides granulatus*, L. Agassiz, *ibid.*, vol. v, pt. i, p. 14 (name only).
1850. *Pomognathus eupterygius*, F. Dixon, Geol. Sussex, p. 367, pl. xxxv, figs. 6, 7.
1888. *Pomognathus eupterygius*, A. S. Woodward, Proc. Geol. Assoc., vol. x, p. 318.
1901. *Halec eupterygius*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, p. 213.

Type.—Imperfect fish from one of the Turonian zones; Willett Collection, Brighton Museum.

Specific Characters.—The type species of the so-called *Pomognathus*, attaining a length of about 40 cm. Length of head with opercular apparatus much exceeding the maximum depth of the trunk, which is probably contained about four times in the length from the pectoral arch to the base of the caudal fin. Length of mandible somewhat exceeding the depth of the head at the occiput; maxilla with 5 to 7 well-spaced teeth; operculum considerably deeper than broad; the infero-posterior spine of the preoperculum short, stout, and ornamented with tubercles. The external tubercular ornament very fine, arranged in more or less radiating lines on the sides of the cranial roof, the supramaxilla, mandible, opercular apparatus, clavicle, supraclavicle, and part of the post-temporal. The stouter rays of the paired and dorsal fins also ornamented with longitudinal series of very fine tubercles. Vertebræ about 45 in number.

Description of Specimens.—The type specimen in the Brighton Museum

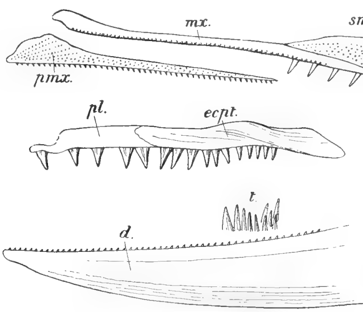

FIG. 11. *Halec eupterygius* (Dixon); diagram of jaws, left side, outer aspect.—English Chalk. *d.*, dentary; *ecpt.*, ectopterygoid; *mx.*, maxilla; *pl.*, palatine; *pmx.*, premaxilla; *smx.*, supramaxilla; *t.*, some inner mandibular teeth.

(Willett Collection, no. 37) is an imperfect and slightly distorted fish, exhibiting nearly all the essential characters of the genus and species. A considerably smaller specimen in the British Museum (no. 43388), which is not distorted, affords additional information concerning the vertebral column and the proportions of the trunk. The two fossils together justify the specific diagnosis just given.

The characters of the skull are shown by the three specimens represented in Pl. XIII, figs. 2, 3, 4, by the type, and by numerous other more or less fragmentary fossils. The maximum width of the cranium, between the hinder part of the orbits, equals about half its total length. The epiotic bones (fig. 3, *epo.*) project considerably backwards, so that the middle of the occipital border, when viewed from above, is observed to be excavated by a sharp re-entering angle. The small posterior median crest of the supraoccipital (*socc.*) extends backwards from

this angle, but does not rise above the plane of the flattened cranial roof. The anterior part of the supraoccipital, which is very small (fig. 4, *socc.*), just enters the exposed cranial roof between the parietal bones, and its outer face is ornamented with rows of tubercles. The parietals (*pa.*) are also extremely small, their outer ornamented face occupying only a little triangular area at the postero-lateral angles of the frontals, with which they unite in an irregular suture. The frontals (*fr.*) constitute nearly the whole of the exposed cranial roof, rapidly expanding to their widest point above the back of the eye and gradually tapering forwards. Their middle portion is smooth, forming the floor of a shallow depression; while the lateral portion is delicately ornamented with close rows of small tubercles, sometimes fused into smooth ridges, which radiate from a point near the middle of the widest part of each bone. The otic region is long and narrow, not projecting outwards beyond the postorbital prominence of the frontal; and it bears one thin longitudinal ridge (*sq.*), which diverges outwards and backwards from the postorbital part of the frontal region, and is ornamented with two rows of fine tubercles. This ridge probably consists in part of the squamosal element. Anteriorly, the frontals overlap the rather short and broad mesethmoid (fig. 3, *eth.*), which appears to be smooth but is imperfectly known (see also B. M. nos. P. 5414, 32335). The antero-lateral portion of each frontal is also quite smooth, and is overlapped by a small loose bone, which has hitherto been interpreted as nasal, but seems rather to correspond with the supraorbital bone of *Aulopus* (Pl. X, fig. 2, *spb.*). This element (obliquely seen in fig. 3, *spb.*) is ovoid in shape, nearly three times as long as broad, widest in front and tapering behind. Its outer face is completely covered with an ornament of rows of tubercles, which radiate from a point in the middle of the broad anterior end.

The eye must have been rather large, and the sclerotic is ossified (fig. 2, *scl.*). No cheek-plates have hitherto been observed.

The mandibular suspensorium is vertical, so that the quadrate articulation is beneath the occipital border. The form and proportions of the suspensorium and palato-pterygoid arcade, shown in fig. 2, closely resemble those of *Cimolichthys.* The ectopterygoid (*ecpt.*) and palatine (*pl.*) appear to be similarly of about equal length, but their dentition is quite characteristic and peculiar. This consists of a single close series of teeth, which are hollow and conical, somewhat laterally compressed, but apparently without sharp edges and clearly not barbed. The dental crowns are smooth, or marked with very fine longitudinal striations; while the widest bases are slightly indented in the middle of the outer face. The hindermost teeth of the ectopterygoid are the smallest members of the series, all comparatively slender and irregularly curved backwards or forwards. They gradually increase in size in front until the two largest teeth appear to occupy the hinder end of the palatine element. Finally, the teeth somewhat decrease in size again towards the anterior end of the arcade. The premaxilla (fig. 7; figs.

1, 6, *pmx.*) is extremely slender, terminating in front in a small triangular expansion, which is longer than deep. This expansion is well shown from the inner side in fig. 7; while its outer face is seen in many specimens (*e.g.*, B. M. nos. 49082, P. 9252) to be ornamented with close rows of tubercles which slightly radiate from its pointed anterior end. The entire length of the oral margin of the bone is ornamented with a cluster of much finer tubercles, which seem to pass almost imperceptibly into the minute teeth. The latter are conical and slender, and arranged in a single, uniform, close series, with their apices slightly inclined backwards. The maxilla (figs. 1, 6, *mx.*) is also very long and slender, and its narrow exposed edge is ornamented with minute tubercles. A considerable length of its hinder portion enters the gape of the mouth, and bears a regular, well-spaced series of five to seven rather large conical teeth, which are slender, straight, sharply pointed, and inclined forwards. The hinder two fifths of the maxilla are deeply overlapped by the large supramaxilla (*smx.*), which is pointed in front and deepest at its rounded hinder end, where it curves slightly upwards. The maximum depth of this bone equals less than one third of its length; and its outer face, except along a narrow margin at the upper edge, is ornamented with fine tubercles, which are arranged in rows chiefly radiating from a point near the hinder end. The length of the mandible is five times as great as its maximum depth; but its lower portion curves so much inwards that, when uncrushed, its true depth is not seen in direct side-view. The very large dentary bone (*d.*) tapers to a point at the symphysis, where its lower or inner edge is apposed to that of its fellow of the opposite side for some distance (fig. 5 *a*, *s.*). Its outer face, crushed completely into view, though flaked, in the original of fig. 1, bears a very fine tubercular ornament, which is partly disposed along some structural lines radiating from the symphysis, and is entirely absent along an elongate-triangular smooth area just below the hinder half of the tooth-bearing border. The mandibular teeth (fig. 5, *d.*) are slender and conical, rounded in section, and with a large central cavity. They form an irregular narrow cluster along the dentary border, quite small at the outer edge, but as large as the opposed upper teeth within. The short articulo-angular bone (figs. 1, 5 *a*, *ag.*) is ornamented in its lower portion with rows of fine tubercles which radiate forwards from its articular end; while its smooth upper part is a direct continuation of the smooth area of the dentary bone. The general aspect of the jaws is diagrammatically represented in Text-fig. 11, p. 51.

The preoperculum (figs. 1, 8, *pop.*) is deep and narrow, almost without a lower limb, but produced at its angle into a short and deep, posteriorly directed spine, of which the pointed apex is broken in the original of fig. 1. The exposed face of the lower end of the bone, with its spine, is ornamented with the usual rows of fine tubercles so characteristic of the fish. The operculum (fig. 8, *op.*) is nearly rhombic in shape, with its postero-inferior angle produced into a short broad spine, which is strengthened by a horizontally directed ridge on the inner face of the

bone. This element is completely ornamented except along a narrow area anteriorly and antero-superiorly; and its rows of tubercles radiate from a point opposite the spine. The suboperculum (fig. 8, *sop.*) is comparatively small and narrow, not curving round the hinder border of the operculum. The rows of tubercles forming its external ornament incline downwards and backwards. The interoperculum must have been very small. Nine branchiostegal rays are seen in the original of fig. 1 (*br.*).

The greater part of the vertebral column is shown in the type specimen in the Willett Collection, and in a smaller specimen in the British Museum (no. 43388). The total number of vertebræ seems to have been about forty-five, and at least twenty-one of these belong to the caudal region. All the centra are longer than deep and much constricted, with very slight development of a lateral longitudinal ridge. Sections seem to show that they were pierced by a delicate persistent strand of notochord (B. M. no. P. 1703 *d*). The neural spines are very slender, each fixed to the postero-superior angle of a low neural arch which occupies only the anterior half of the supporting centrum (fig. 1). The ribs are also slender and nearly straight, directly articulating with the middle of each centrum. They are antero-posteriorly compressed, not rounded in section. The neural and hæmal spines in the caudal region are rather short and much inclined backwards.

The pectoral arch is suspended from the cranium by a pair of large laminar post-temporal elements (the left shown in fig. 9), which impinge on the supraoccipital at the middle of the occipital border. They are thin and nearly rhomboidal in shape, about twice as long as broad. The greater part of their outer face is smooth, the ornament of radiating lines of fine tubercles being restricted to a small elongate-ovoid area postero-externally. The supraclavicle is deep and narrow, ornamented at its hinder margin with a few rows of small tubercles, which radiate slightly at the top, but mainly follow its long axis. The clavicle (fig. 1, *cl.*) consists mainly of a lamina of bone extended in a plane at right angles to the axis of the trunk; but it also bears a small outer plate in the plane of the flank. In the specimen figured the bone is incomplete below, and its outer plate is smooth; but the latter must have originally borne a tubercular ornament, which is shown in other specimens (*e. g.*, B. M. no. P. 3657). The post-clavicle is a small, narrow, smooth lamina, which is inclined downwards and backwards from beneath the upper part of the clavicle. The element of both sides is shown in the original of fig. 1 (*pcl.*), and that of the left side is seen in fig. 8 (*pcl.*). The coracoid bears a long and narrow process extending forwards to the symphysis of the clavicles (B. M. no. 39073). The pectoral fin (fig. 1, *pct.*) is rather large, long and narrow, consisting of about twelve to fifteen rays, each of which has a long unarticulated base ornamented on its front edge with very fine tubercles. As shown by the type specimen, the pelvic fins are nearly as large as the pectorals, each with at least eight rays supported by a much-expanded pelvic bone. There are traces of these fins and their supports in the

original of fig. 1 (*plv.*), where they are shown to be opposed to the hinder end of the short dorsal fin (*do.*). The latter is triangular in shape, with about twelve rays, of which the length of the foremost and longest is less than the depth of the trunk at its insertion. Its five anterior rays are especially stout, and ornamented in front with longitudinal rows of fine tubercles; but all are articulated distally. Some of the supports of the anal fin in B. M. no. 43388 indicate that it must have been comparatively small and remote; while remains of the caudal fin both in this and the type specimen show that it was relatively stout and almost certainly forked.

No traces of scales have hitherto been observed; but there is a longitudinal series of four or five overlapping dermal scutes on each side of the caudal pedicle just in front of the caudal fin. These are seen both in the type specimen and in B. M. no. 43388, but are too imperfect for description.

Horizons and Localities.—Zones of *Holaster subglobosus* to *Terebratulina gracilis:* neighbourhood of Lewes, Sussex. Zone of *Holaster subglobosus:* Burham, Halling, and Dover, Kent; Glynde, Sussex. Zone of *Terebratulina gracilis* or *Rhynchonella cuvieri:* Burham. Zone of *Micraster coranguinum:* Gravesend, Kent.

Genus **ENCHODUS,** Agassiz.

Enchodus, L. Agassiz, Poiss. Foss., Feuill. 1835, p. 55, and vol. v, pt. i, 1844, p. 64.
Isodus, J. J. Heckel, in Russegger's Reisen, vol. ii, pt. iii, 1849, p. 342.
Phasganodus, J. Leidy, Proc. Acad. Nat. Sci. Philad., 1857, p. 167.
Ischyrocephalus, W. von der Marck, Zeitschr. deutsch. geol. Ges., vol. x, 1858, p. 248.
(?) *Tetheodus,* E. D. Cope, Bull. U.S. Geol. Surv. Territ., no. 2, 1874, p. 43.
Solenodon, D. G. Kramberger (*non* Brandt, 1833), Jahrb. k.-k. geol. Reichsanst., vol. xxxi, 1881, p. 373.
Holcodon, D. G. Kramberger, Rad Jugoslav. Akad., vol. lxxii, 1885, p. 18.
Eurygnathus, J. W. Davis, Trans. Roy. Dublin Soc. [2], vol. iii, 1887, p. 601.

Generic Characters.—Trunk elongate-fusiform, both this and the head laterally compressed. Cranial roof exhibiting a deep median longitudinal depression, its lateral and occipital margins ornamented, like the other external bones, with ridges and tubercles of ganoine. Mandible a little prominent, provided with an inner widely-spaced series of large slender teeth, the largest in front, also a marginal series of minute teeth, all nearly or completely solid; premaxilla in the form of a vertical lamina, deepest in front, tapering behind, and with a single spaced series of small teeth; maxilla long and slender, either finely toothed or toothless at the oral border; palatine thickened and tumid, with only one large tooth fixed at its anterior end; ectopterygoid robust, with a single spaced series of large slender teeth, gradually diminishing in size backwards; no teeth barbed. Preoperculum

very narrow and deep; operculum strengthened on the inner side by a ridge extending horizontally backwards from the point of suspension; branchiostegal rays about 12 to 16 in number. Vertebræ 40 to 50 in number, about half being caudal; the centra at least as long as deep, constricted mesially, and marked with small irregular longitudinal ridges. All except the foremost rays of each fin finely divided distally, but none excessively elongated. No postclavicular plate. Pectoral fins large, pelvic fins much smaller and arising far forwards; dorsal and anal fins large, neither much longer than deep, the former arising much in advance of the middle point of the trunk, the latter also far forwards; a posterior adipose dorsal fin observed in a few well-preserved specimens; caudal fin forked, with curved fulcral rays and stout, articulated, undivided rays at its base both above and below. Rudimentary dermal scutes, not overlapping, in a single median series between the occiput and the dorsal fin, and along the course

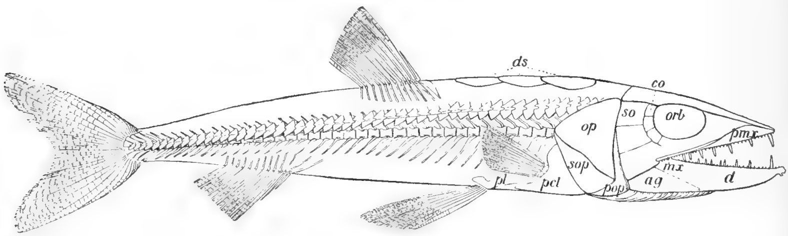

Fig. 12. *Eurypholis boissieri*, Pictet; restoration (omitting external ornament), about three quarters nat. size.—Upper Cretaceous; Hakel, Mt. Lebanon. *ag.*, angular; *co.*, circumorbitals; *d.*, dentary; *d.s.*, dorsal scutes; *mx.*, maxilla; *op.*, operculum; *orb.*, orbit; *pcl.*, postclavicular plate (obscuring the pectoral arch to which the basals of the fin are attached); *pl.*, pelvic fin-support; *pmx.*, premaxilla (with large teeth of palatine and ectopterygoid showing within); *pop.*, preoperculum; *so.*, suborbitals; *sop.*, suboperculum; lateral line traversing row of scutes above vertebral column. (From 'Catal. Foss. Fishes B. M.,' pt. iv, 1901.)

of the lateral line; a pair of enlarged hook-shaped dermal scutes at the base of the tail, one on either side of the caudal pedicle.

Type Species.—Enchodus lewesiensis, from the English Chalk.

Remarks.—Complete skeletons of species of this genus are known only from the Upper Cretaceous of the Lebanon and Westphalia, perhaps also from the Cretaceous of Comen, Istria. The remains from the English Chalk are comparatively fragmentary, but important as exhibiting the osteology of the head. The general appearance of the fish would closely resemble that of *Eurypholis* (Text-fig. 12), which differs from *Enchodus* in the relatively large size of its pelvic fins, the possession of a large postclavicular plate, and the somewhat greater development of its dermal scutes.

PLATE I.

Fig.		Page.
1.	*Berycopsis elegans*, Dixon; right lateral aspect of fish.—Chalk; Sussex. Dixon Collection (B. M. no. 25881). *a.*, expanded foremost support of anal fin; *ag.*, articulo-angular; *ao.*, antorbital; *co.*, circumorbital ring; *d.*, dentary; *iop.*, interoperculum; *mx.*, maxilla; *n.*, free dorsal fin-supports; *op.*, operculum; *p.*, remains of pectoral fin; *pmx.*, pre-maxilla; *pop.*, preoperculum; *qu.*, quadrate; *smx. 2*, posterior supra-maxilla; *socc.*, supraoccipital crest; *sop.*, suboperculum.	6.
2.	Ditto; head, right lateral aspect.—Probably from zone of *Holaster planus;* Cuxton, Kent. Harford Collection (B. M. no. P. 5696). *br.*, branchiostegal rays; *c.*, coracoid, with scapula above; *cl.*, clavicle; *ecpt.*, ectopterygoid; *f.*, foramen in scapula; *hm.*, hyomandibular; *mpt.*, metapterygoid; *pcl.*, post-clavicle; *prf.*, prefrontal (ectethmoid); *smx. 1*, anterior supramaxilla; *s.*, suspension of operculum; other letters as above.	7.
3.	Ditto; part of roof of cranium seen from above.—Chalk; Kent. Egerton Collection (B. M. no. P. 1951). *fr.*, frontal; *socc.*, supraoccipital crest; *spb.*, supraorbital flange of frontal.	6.
4.	Ditto; fragment of trunk showing scales and anterior part of dorsal fin with spines.—Chalk; Kent. Mrs. Smith's Collection (B. M. no. 49053).	10.

All the figures of the natural size.

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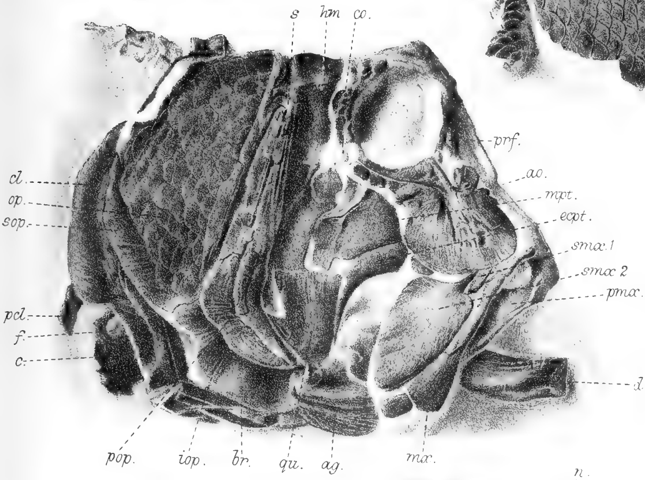

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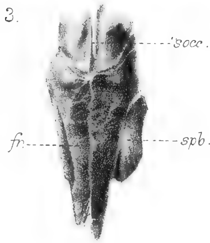

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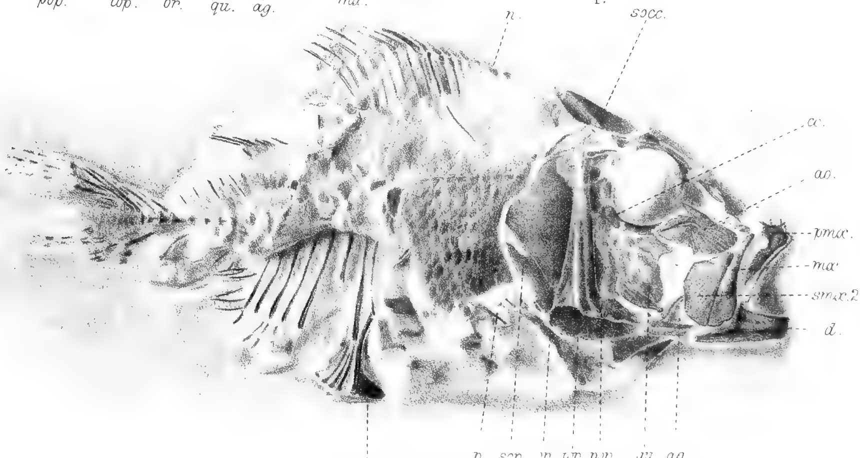

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Mintern Bros imp.

Berycopsis.

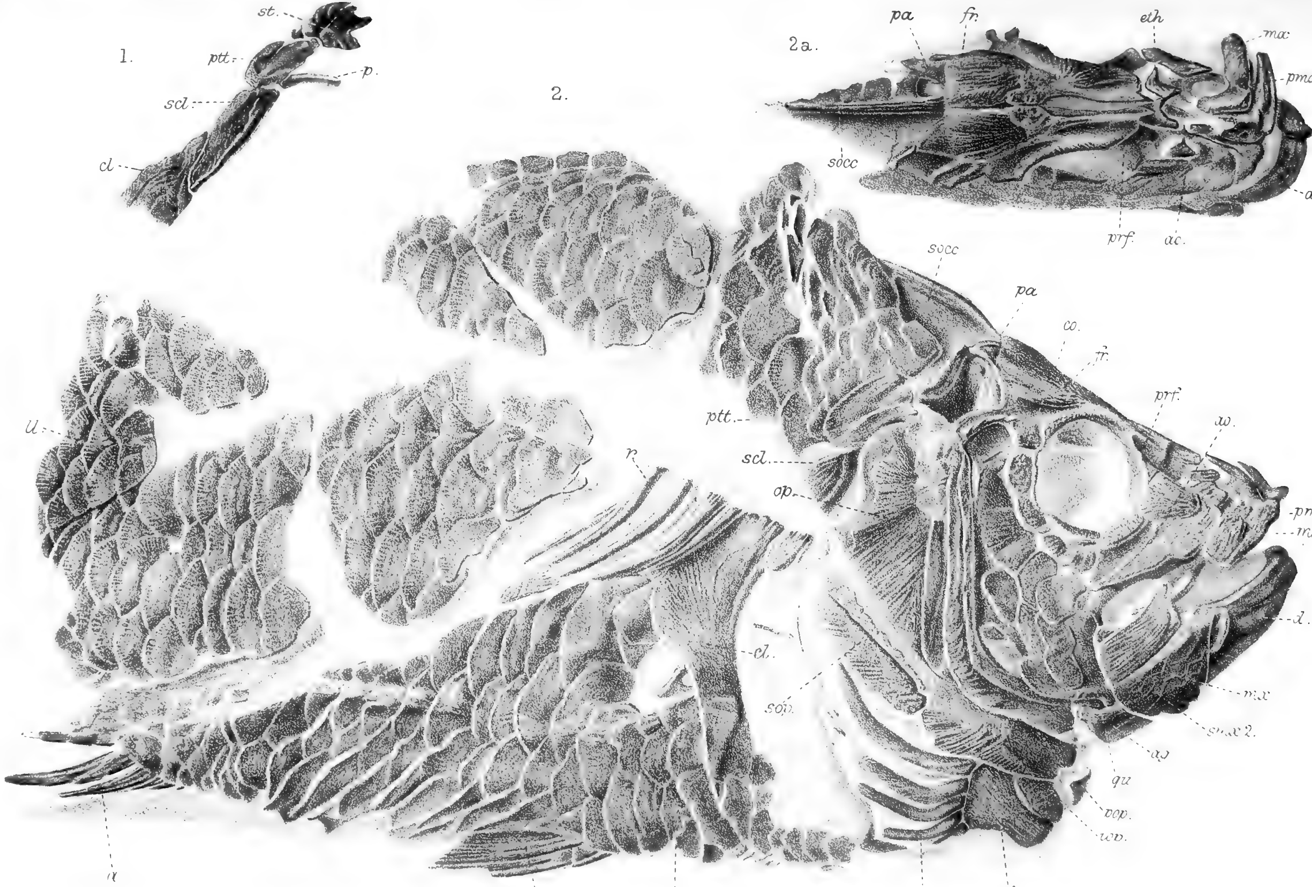
PLATE II.

Fig. | Page.

1. *Berycopsis elegans*, Dixon; upper part of right side of pectoral arch, outer aspect.—Zone of *Holaster subglobosus;* Burham, Kent. Harford Collection (B. M. no. P. 5683). *cl.*, clavicle; *ptt.*, post-temporal, with process (*p.*) for articulation with pterotic; *scl.*, supraclavicle; *st.*, supratemporal. 9.

2. *Berycopsis major*, sp. nov.; head and part of trunk, right lateral aspect, and (2 *a*) head, upper aspect.—Zone of *Holaster planus* (?); Cuxton, Kent. Harford Collection (B. M. no. P. 5686). *a.*, anal fin; *ag.*, articulo-angular; *ao.*, antorbital; *br.*, branchiostegal rays; *ch.*, ceratohyal; *cl.*, clavicle; *co.*, circumorbital ring; *d.*, dentary; *eth.*, mesethmoid; *fr.*, frontal; *iop.*, interoperculum; *ll.*, lateral line; *mx.*, maxilla, wanting middle portion; *op.*, operculum; *pa.*, parietal; *plv.*, pelvic fin; *pmx.*, premaxilla; *pop.*, preoperculum; *prf.*, prefrontal; *ptt.*, post-temporal; *qu.*, quadrate; *r.*, ribs; *sc.*, scapula; *scl.*, supraclavicle; *smx. 2*, supramaxilla; *socc.*, supraoccipital; *sop.*, suboperculum. 11.

Figures of the natural size.



A. H. Searle del et lith. Mintern Bros imp.

Berycopsis.

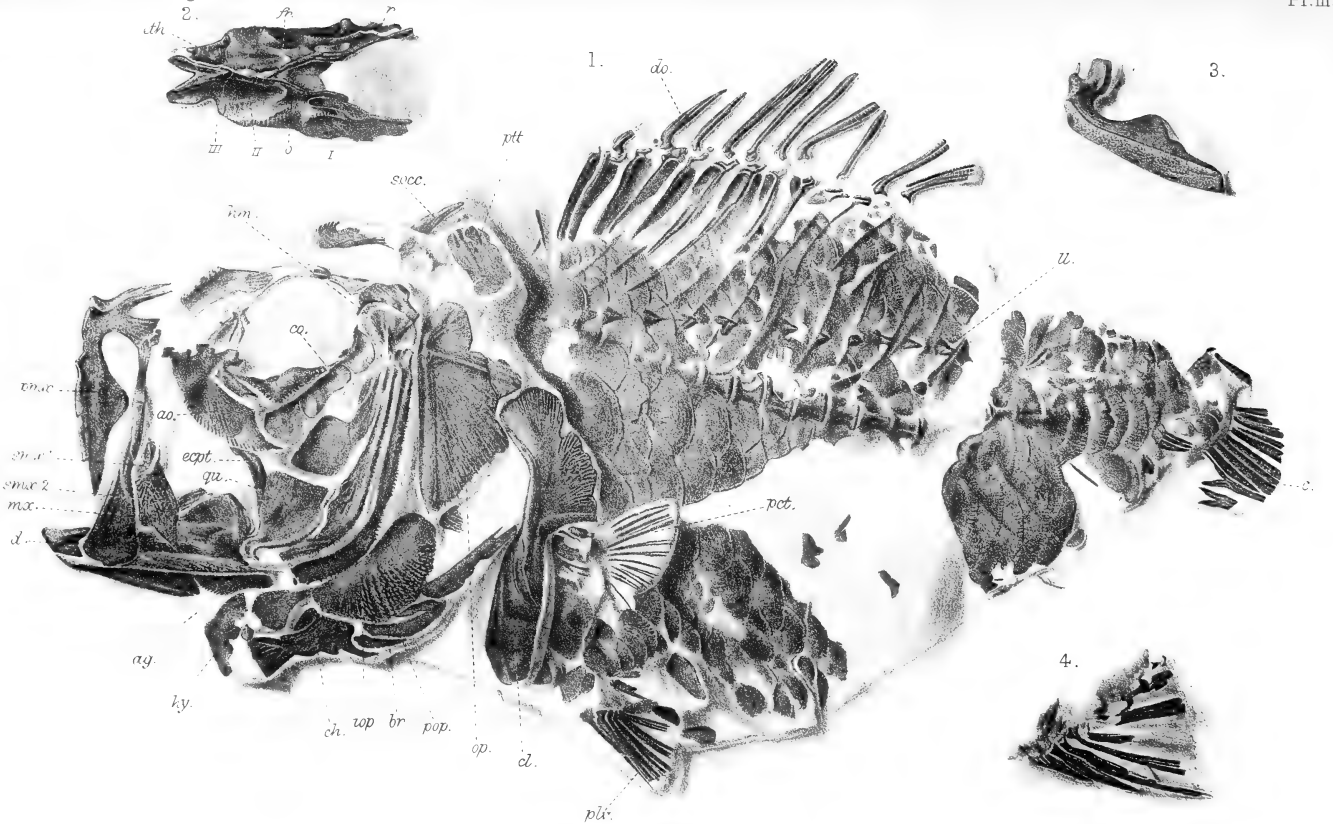
PLATE III.

Fig.		Page.
1.	*Hoplopteryx lewesiensis* (Mantell); left lateral aspect of fish.—Chalk; neighbourhood of Rochester, Kent. B. M. no. 35712. *ag.*, articulo-angular; *ao.*, antorbital; *br.*, branchiostegal rays; *c.*, caudal fin; *ch.*, ceratohyal; *cl.*, clavicle; *co.*, circumorbitals; *d.*, dentary; *do.*, dorsal fin; *ecpt.*, ectopterygoid; *hm.*, hyomandibular; *hy.*, hypohyal; *iop.*, interoperculum; *ll.*, lateral line; *mx.*, maxilla; *op.*, operculum; *pct.*, pectoral fin; *plv.*, pelvic fin; *pmx.*, premaxilla; *pop.*, preoperculum; *ptt.*, post-temporal; *qu.*, quadrate; *smx. 1, 2*, supramaxillæ; *socc.*, supraoccipital crest.	16.
2.	Ditto; cranium, from above, the hinder fossa filled with chalk.—Chalk; probably from Burham, Kent. Mrs. Smith's Collection (B. M. no. 49037). *eth.*, mesethmoid; *fr.*, frontal; *r.*, ridge bounding posterior fossa; o., median slime-pit; I, II, III, lateral slime-pits.	16.
3.	Ditto; right premaxilla, inner aspect.—Chalk; Burham. Toulmin Smith Collection (B. M. no. 41692).	17.
4.	Ditto; anterior part of anal fin, showing four spines.—Chalk; probably Sussex. B. M. no. 79.	20.

All the figures of the natural size.

A. S. Woodward. English Chalk Fishes.

Pl. III.



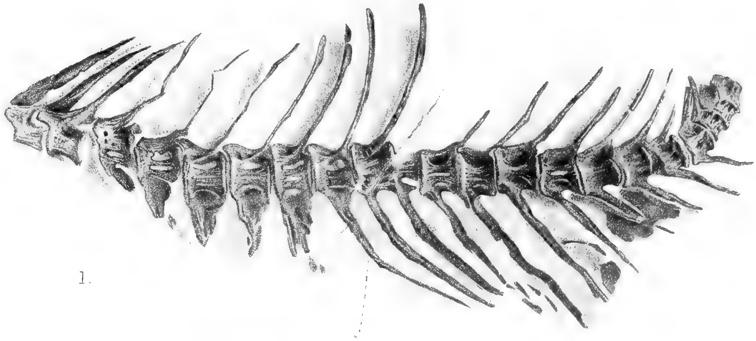
A H Searle del et lith.

Mintern Bros. imp.

Hoplopteryx.

PLATE IV.

Fig.		Page.
1.	*Hoplopteryx lewesiensis* (Mantell); vertebral column, left lateral aspect, nat. size.—Chalk; Lewes. Capron Collection (B. M. no. 49862). *c.*, hæmal arch of first caudal vertebra.	19.
2.	*Hoplopteryx superbus* (Dixon); ventral aspect of trunk, nat. size.—Chalk; probably Sussex. Beckles Collection (B. M. no. P. 9153). *a.*, anal fin; *plv.*, pelvic fins.	21.
3.	Ditto; imperfect fish, left lateral aspect, one half nat. size.—Chalk; near Maidstone. B. M. no. 32340. *a.*, anal fin; *c.*, caudal fin; *d.*, dorsal fin; *op.*, operculum; *plv.*, pelvic fins.	21.



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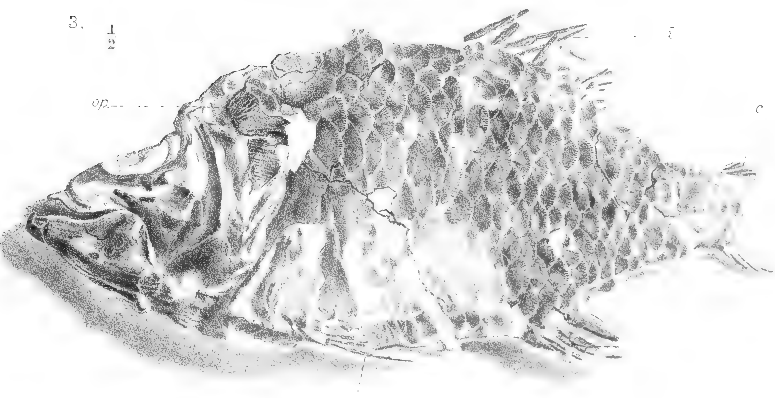


A. H. Searle del et lith

Mintern Bros imp

Hoplopteryx.

PLATE V.

PAGE.

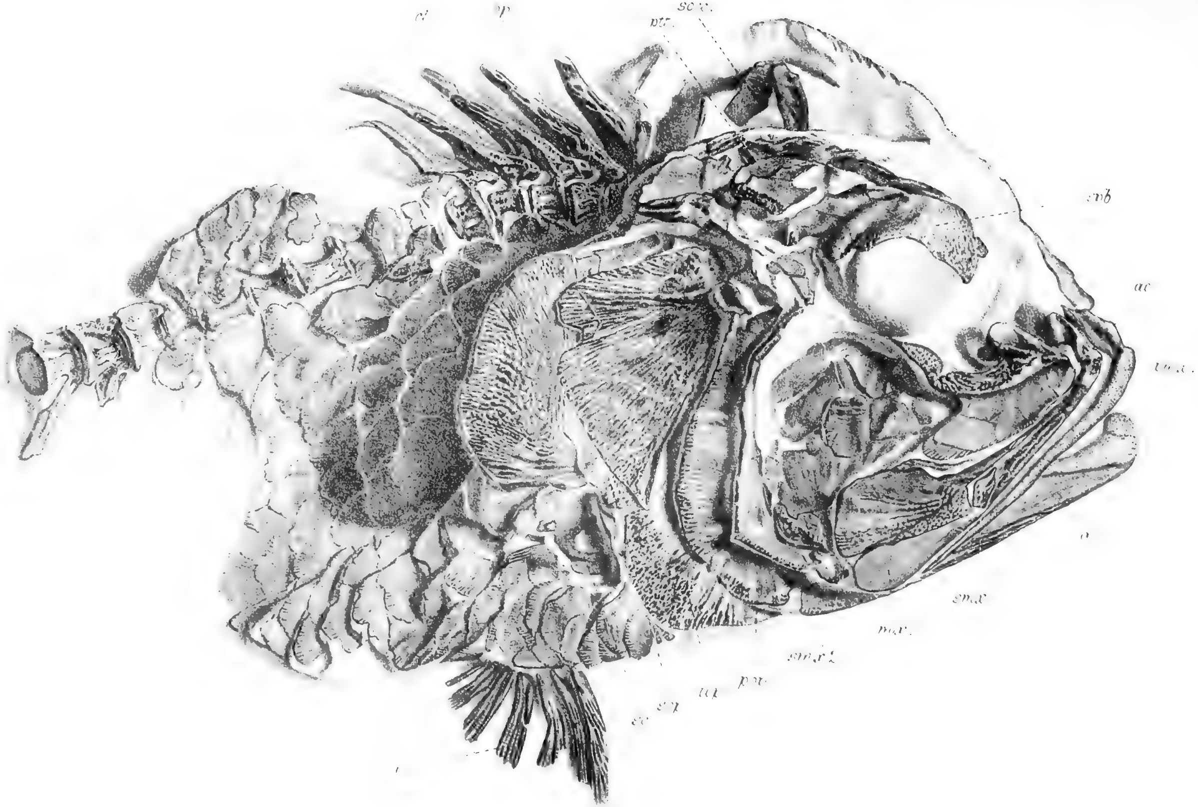
Hoplopteryx superbus (Dixon); photograph of slab of Chalk, probably from Sussex, one half nat. size, showing group of remains of several individuals. Beckles Collection (B. M. no. P. 9153). 22.

plopteryx.

PLATE VI.

PAGE.

Hoplopteryx superbus (Dixon); head and imperfect trunk, partially distorted, right lateral aspect, nat. size.—Chalk; Kent. B. M. no. 33486. *ao.*, antorbital; *cl.*, hinder expansion of clavicle; *d.*, dentary; *iop.*, interoperculum; *mx.*, maxilla; *op.*, operculum; *plv.*, base of pelvic fin; *pmx.*, premaxilla; *pop.*, preoperculum; *ptt.*, post-temporal; *sc.*, scapula; *smx. 1, 2*, supramaxillæ; *socc.*, supraoccipital crest; *sop.*, suboperculum; *sph.*, supraorbital flange of frontal. 21.



A. H. Searle del. et lith.

Mintern Bros. imp.

Hoplopteryx.

PLATE VII.

Fig.		Page.
1.	*Hoplopteryx lewesiensis* (Mantell); inner aspect of left mandibular suspensorium, pterygo-quadrate region, hyoid arch, and other bones.—Zone of *Terebratulina gracilis;* Cuxton, Kent. Harford Collection (B. M. no. P. 5689). *ch.*, ceratohyal; *ecpt.*, ectopterygoid; *eph.*, epihyal; *hy*, hypohyal; *hm.*, hyomandibular; *ih.*, interhyal (stylohyal); *mpt.*, metapterygoid; *op.*, part of operculum; *pl.*, palatine; *ptt.*, post-temporal; *qu.*, quadrate; *scl.*, supraclavicle; *sy.*, symplectic.	18.
2.	*Hoplopteryx superbus* (Dixon); head with opercular apparatus, right lateral aspect.—Probably zone of *Rhynchonella cuvieri;* Halling, Kent. B. M. no. 41104. *ao.*, antorbital; *d.*, part of dentary; *fr.*, frontal; *iop.*, interoperculum; *mx.*, part of maxilla; *op.*, operculum; *pmx.*, part of premaxilla; *pop.*, preoperculum; *qu.*, quadrate; *sop.*, suboperculum.	21.
3, 4.	Ditto; two scales, outer aspect, the ornamented exposed area to the left.—Chalk; Kent. B. M. no. 33486.	22.
5.	Ditto; inner view of overlapping scales, showing tuberculations.—A Turonian zone; Southeram, Lewes. Dixon Collection (B. M. no. 25959).	22.
6.	*Homonotus dorsalis*, Dixon; imperfect trunk, left lateral aspect, with scale (6*a*) enlarged twice.—Zone of *Micraster coranguinum;* Gravesend, Kent. Bowerbank Collection (B. M. no. 39074). *a.*, anal fin; *c.*, caudal fin; *cl.*, plate of clavicle; *d.*, dorsal fin; *plv.*, pelvic fin.	27.
7.	Ditto; imperfect fish, left lateral aspect.—Zone of *Micraster coranguinum;* Northfleet, Kent. B. M. no. 33230. *md.*, portion of mandible; *op.*, portion of operculum; other letters as in fig. 6.	27.
8.	*Homonotus rotundus*, sp. nov.; distorted small fish, right lateral aspect, the type specimen.—Zone of *Holaster subglobosus;* Page's Pit, Westwell, near Charing, Kent. Harris Collection (B. M. no. P. 315). Lettering as in fig. 6.	28.

All the figures, except 6*a*, of the natural size.

PALÆONTOGRAPHICAL SOCIETY, 1902.

A.S.Woodward, English Chalk Fishes.

Pl. VII

A.H.Searle del. et lith.

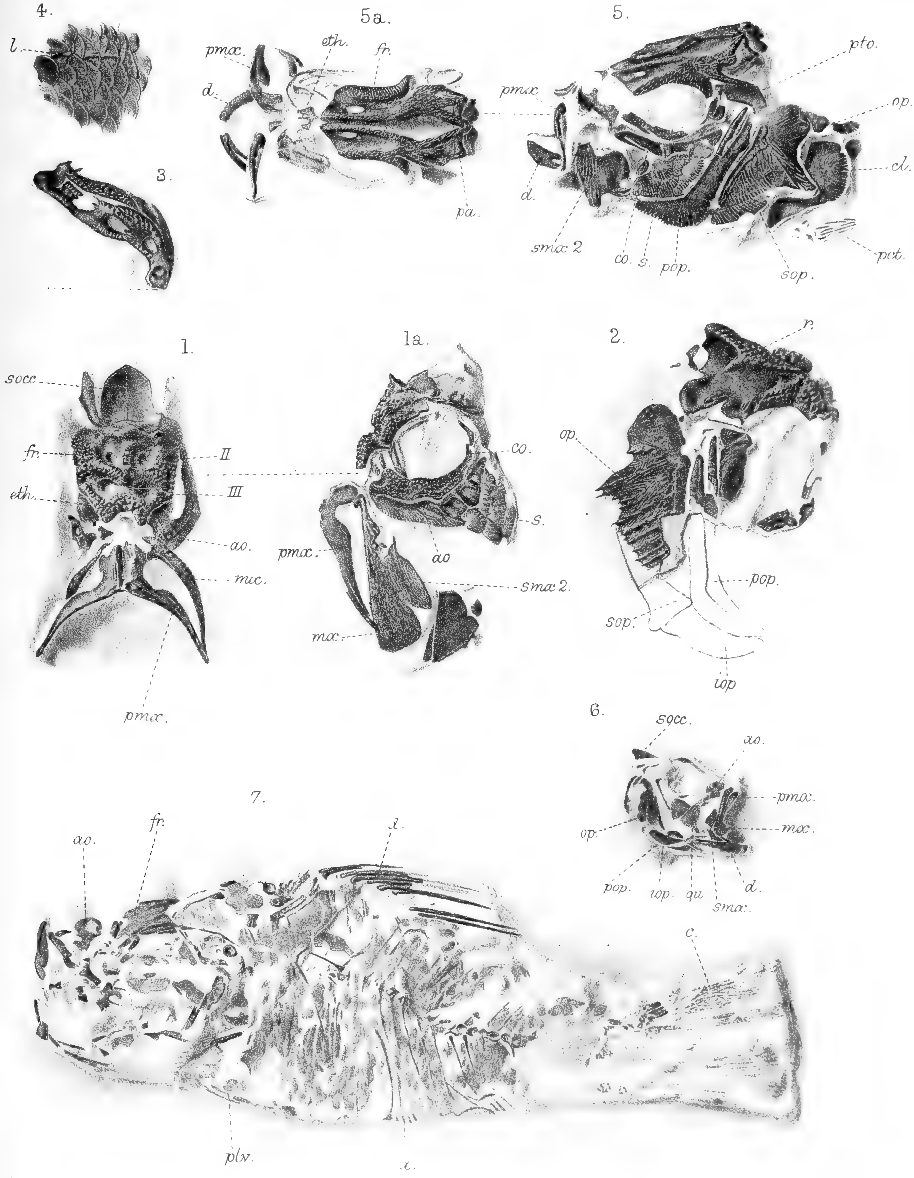
Mintern Bros. imp.

1-5. Hoplopteryx. 6-8. Homonotus.

PLATE VIII.

Fig.		Page.
1.	*Hoplopteryx simus*, sp. nov.; head from anterior and (1 *a*) left lateral aspects.—Chalk; Kent. Harford Collection (B. M. no. P. 5700). *ao.*, antorbital; *co.*, circumorbital ring; *eth.*, mesethmoid; *fr.*, frontal; *mx.*, maxilla; *pmx.*, premaxilla; *s.*, scales on cheek; *smx. 2*, posterior supramaxilla; *socc.*, supraoccipital, viewed from above; II, III, paired slime-cavities.	23.
2.	Ditto; hinder part of cranium with upper part of opercular apparatus, lower part restored in outline.—Chalk; Kent. Mrs. Smith's Collection (B. M. no. 49074). *iop.*, interoperculum; *op.*, operculum; *pop.*, preoperculum; *r.*, ridge bounding hollow on cranial roof originally occupied by muscles; *sop.*, suboperculum.	23.
3.	Ditto; right mandibular ramus, inferior aspect, showing bridges of bone over large slime-canal.—Chalk; Kent. Mrs. Smith's Collection (B. M. no. 49073). Dotted line indicates long axis of head.	24.
4.	Ditto; some scales of flank, showing course of lateral line (*l.*).—English Chalk. B. M. no. P. 387.	24.
5.	*Trachichthyoides ornatus*, gen. et sp. nov.; head with opercular apparatus, from left lateral and upper (5 *a*) aspects.—Chalk; Bromley, Kent. Bowerbank Collection (B. M. no. 39076). *cl.*, clavicle; *d.*, dentary; *pa.*, parietal; *pct.*, pectoral fin; *pto.*, pterotic region; other letters as in figs. 1, 2.	29.
6.	*Homonotus dorsalis*, Dixon; head with opercular apparatus, right lateral aspect.—Zone of *Holaster subglobosus;* Burham, Kent. B. M. no. 41673. *ao.*, antorbital; *d.*, dentary; *qu.*, quadrate; other letters as in figs. 1, 2.	25.
7.	Ditto; imperfect fish, left lateral aspect.—Zone of *Micraster coranguinum;* Bromley, Kent. B. M. no. 43264. *a.*, anal fin; *ao.*, part of antorbital; *c.*, caudal fin; *d.*, dorsal fin-spines, partly restored from counterpart; *fr.*, frontal region; *plv.*, pelvic fins.	25.

All the figures of the natural size.



A.H.Searle del.et lith.

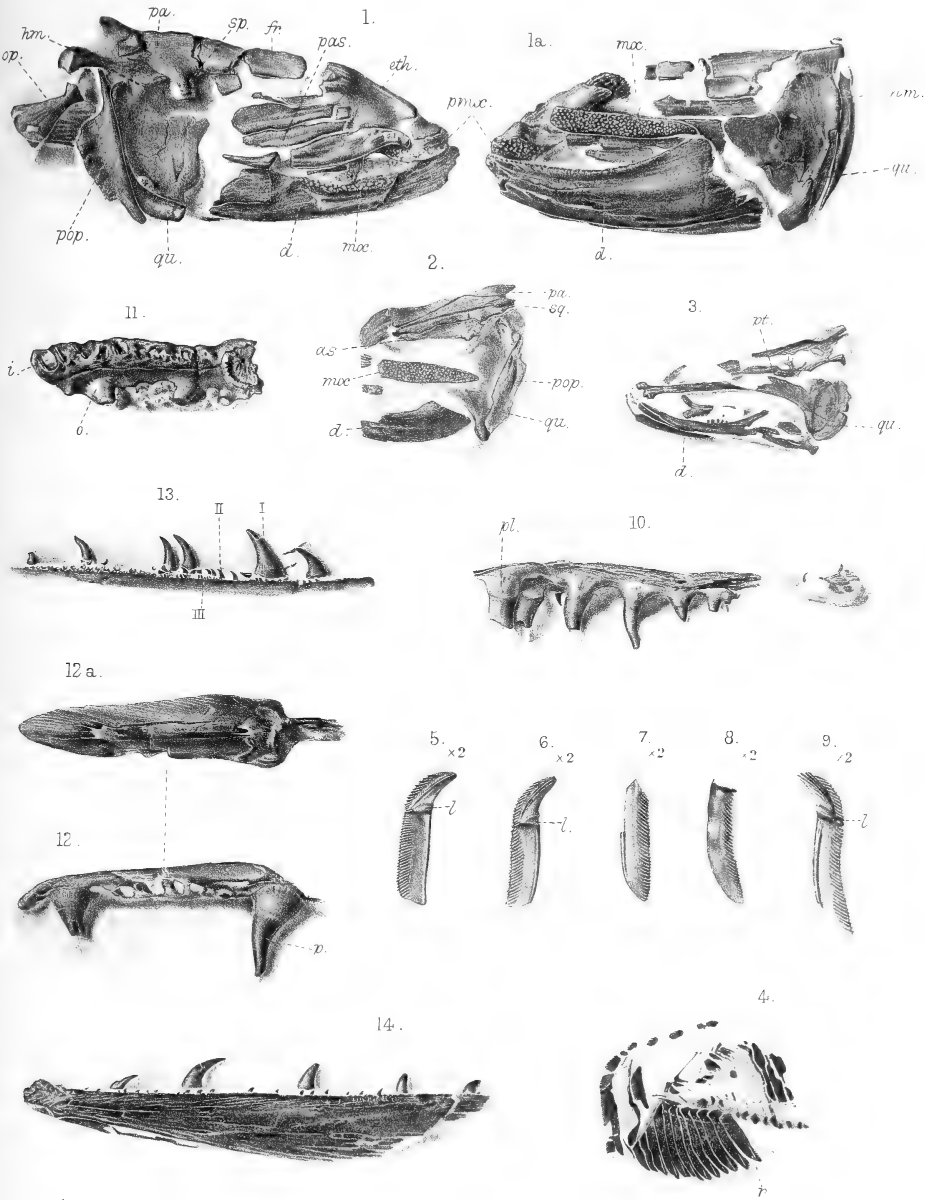
Mintern Bros. imp.

1-4. Hoplopteryx. 5. Trachichthyoides.
6,7. Homonotus.

PLATE IX.

Fig.		Page.
1.	*Urenchelys anglicus*, A. S. Woodward; head with opercular apparatus, right and left (1 *a*) lateral aspects, the type specimen.—A Turonian zone; Houghton, Sussex. Willett Collection no. 100, Brighton Museum. *d.*, dentary; *eth.*, mesethmoid; *fr.*, frontal; *hm.*, hyomandibular; *mx.*, maxilla; *op.*, operculum; *pa.*, parietal; *pas.*, probably parasphenoid; *pmx.*, premaxilla; *pop.*, preoperculum; *qu.*, quadrate; *sp.*, sphenotic (postfrontal).	31.
2.	Ditto; hinder part of head, left lateral aspect.—English Chalk. Egerton Collection (B. M. no. P. 4510 *a*). *as.*, alisphenoid; *sq.*, squamosal; other letters as in fig. 1.	31.
3.	Ditto; remains of skull, quadrate (*qu.*), pterygoid arcade (*pt.*), and mandible (*d.*).—Probably a Turonian zone; Dover. Daniels Collection (B. M. no. 36133).	31.
4.	*Prionolepis angustus*, Egerton; scales, chiefly shown from inner aspect, the type specimen.—Zone of *Holaster subglobosus;* Burwell, Cambridgeshire. Dixon Collection (B. M. no. P. 9253). *r.*, vertical ridge on inner face of scale.	43.
5—8.	Ditto; four imperfect scales, outer aspect, twice nat. size, two showing upper end, two showing lower end.—Zone of *Holaster planus;* Swaffham, Norfolk. C. B. Rose Collection (B. M. no. 29040). *l.*, course of lateral line.	43.
9.	Ditto; scale traversed by lateral line (*l.*), outer aspect, twice nat. size.—Zone of *Holaster subglobosus;* Calne, Wiltshire. Cunnington Collection (B. M. no. 46393).	43.
10.	*Cimolichthys lewesiensis*, Leidy; right palato-pterygoid arcade, inner aspect.—Probably a Turonian zone; Burham, Kent. Egerton Collection (B. M. no. P. 1810 *c*). *pl.*, posterior inner palatine tooth.	46.
11.	Ditto; right palatine, oral face, showing two rows of teeth.—Probably a Turonian zone; Burham. B. M. no. 36750. *i.*, sockets for inner row of teeth; *o.*, base of an outer tooth.	47.
12.	Ditto; right palatine, inner and upper (12 *a*) aspects.—English Chalk. B. M. no. P. 407. *p.*, large posterior inner tooth.	47.
13.	Ditto; right mandibular dentition, outer aspect.—Zone of *Holaster subglobosus;* Halling, Kent. Bowerbank Collection (B. M. no. 39122). Three series of teeth numbered I, II, III.	48.
14.	Ditto; left dentary, outer aspect.—Probably a Turonian zone; Kent. Mrs. Smith's Collection (B. M. no. 49066).	47.

All the figures, except 5 to 9, of the natural size.



A.H.Searle del. et lith.

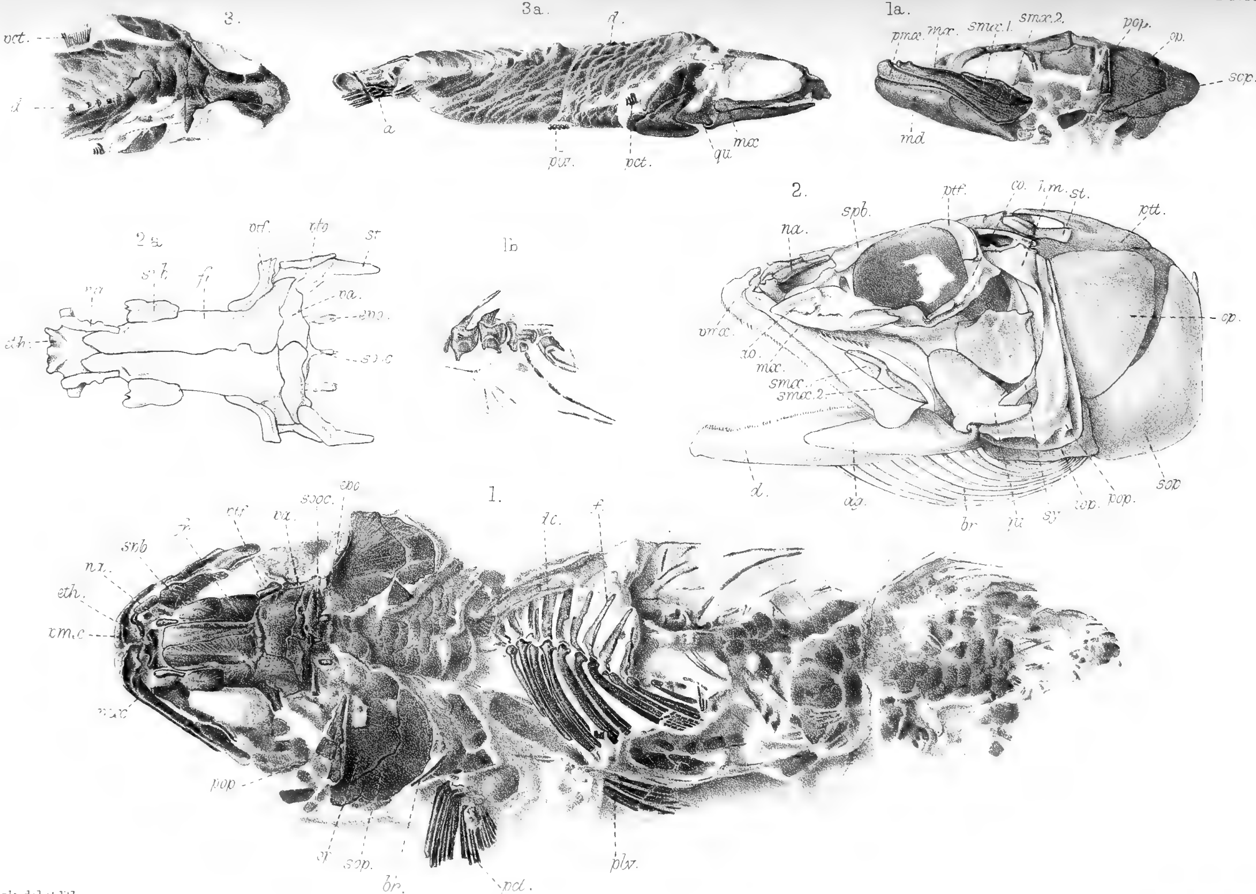
Mintern Bros. imp.

1-3. Urenchelys. 4-9. Prionolepis. 10-14. Cimolichthys.

PLATE X.

Fig.		Page
1.	*Sardinioides illustrans*, sp. nov.; imperfect, vertically crushed fish, upper aspect, the type specimen; also lateral view of head of the same (1 *a*), and some hinder abdominal vertebræ (1 *b*).—English Chalk. Enniskillen Collection (B. M. no. P. 3977). *br.*, branchiostegal rays; *do.*, dorsal fin-rays; *epo.*, epiotic; *eth.*, mesethmoid; *f.*, dorsal fin-supports; *fr.*, frontal; *md.*, mandible; *mx.*, maxilla; *na.*, nasal; *op.*, operculum; *pa.*, parietal; *pct.*, pectoral fin; *plv.*, pelvic fin; *pmx.*, premaxilla; *pop.*, preoperculum; *ptf.*, postfrontal; *smx. 1, 2*, supramaxillæ; *socc.*, supraoccipital; *sop.*, suboperculum; *spb.*, supraorbital.	34.
2.	*Aulopus filamentosus*, Cuvier; left lateral aspect of head with opercular apparatus, and upper view of skull (2 *a*).—Recent Fish. *ag.*, articulo-angular; *ao.*, antorbital; *co.*, circumorbital ring; *d.*, dentary; *hm.*, hyomandibular; *iop.*, interoperculum; *pto.*, pterotic; *ptt.*, post-temporal; *qu.*, quadrate; *st.*, supratemporal; *sy.*, symplectic; other letters as in fig. 1.	33.
3.	*Acrognathus boops*, Agassiz; distorted head and trunk, upper aspect (in part) and right lateral aspect (3 *a*), the type specimen.—Chalk; Lewes. Mantell Collection (B. M. no. 4304). *a.*, anal fin; *d.*, dorsal fin; *mx.*, maxilla; *pct.*, pectoral fin; *plv.*, pelvic fin; *qu.*, quadrate.	36.

All the figures of the natural size.



1. Sardinioides. 2. Aulopus. 3. Acrognathus.

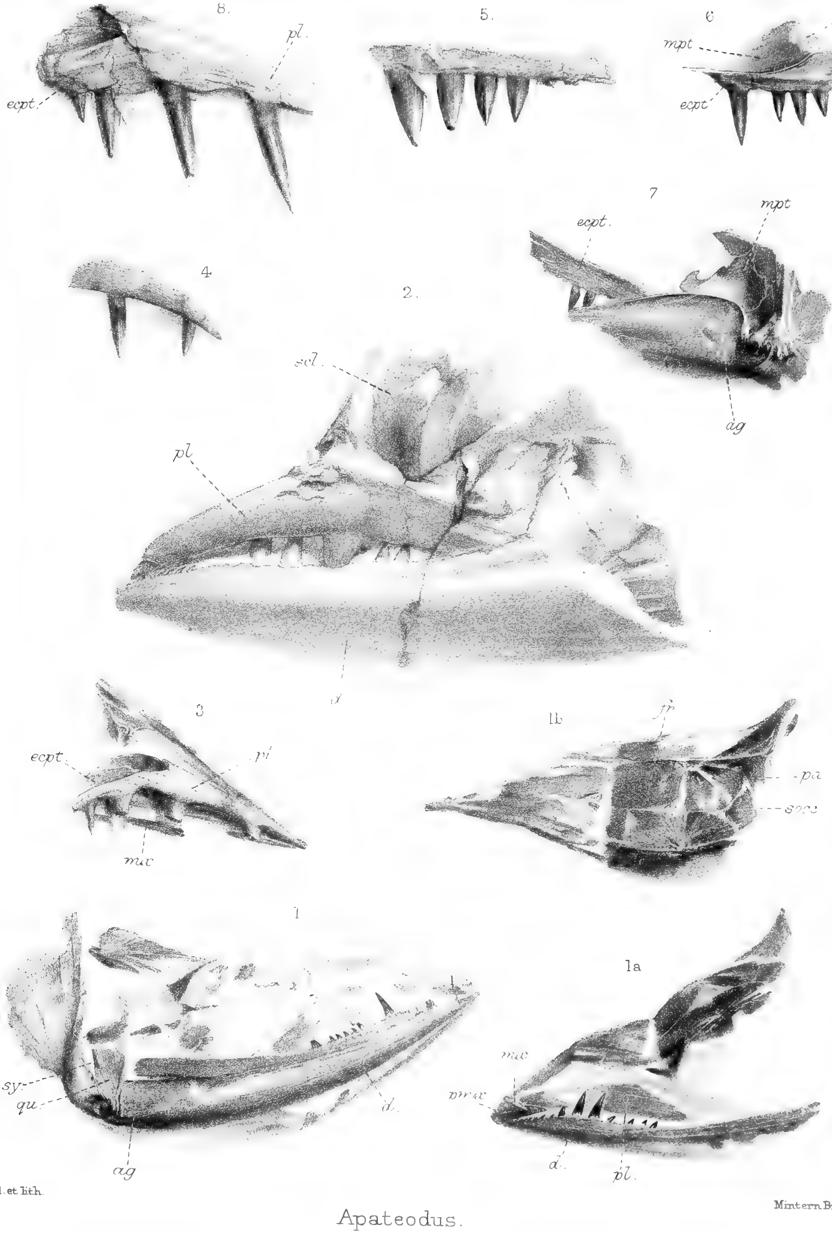
A H Searle del. et lith.

Mintern Bros imp.

PLATE XI.

FIG.		PAGE.
1.	*Apateodus striatus*, A. S. Woodward; distorted head, right lateral, left lateral (1 *a*), and upper (1 *b*) aspects, the type specimen.—A Turonian zone; Southeram, Lewes. Capron Collection (B. M. no. 49821). *ag.*, articulo-angular; *d.*, dentary; *fr.*, frontal; *mx.*, maxilla; *pa.*, parietal; *pl.*, palatine; *pmx.*, premaxilla; *qu.*, quadrate; *socc.*, supraoccipital; *sy.*, space for symplectic.	39.
2.	Ditto; portion of head, left lateral aspect.—Zone of *Holaster subglobosus;* Merstham. B. M. no. P. 9015. *scl.*, sclerotic ring; other letters as in fig. 1.	39.
3.	Ditto; portion of rostrum, showing inner aspect of left ectopterygoid (*ecpt.*), palatine (*pl.*), and fragment of maxilla (*mx.*).—A Turonian zone; Cuxton, Kent. Harford Collection (B. M. no. P. 5666).	40.
4.	Ditto; right palatine, outer aspect.—Chalk; Kent. Mrs. Smith's Collection (B. M. no. 49067).	40.
5.	Ditto; imperfect ectopterygoid.—A Turonian zone; Burham, Kent. B. M. no. 33309.	40.
6.	Ditto; hinder end of left pterygoid arcade, outer aspect.—Ibid. S. J. Hawkins Collection (B. M. no. P. 9042). *ecpt.*, ectopterygoid; *hm.*, hyomandibular; *mpt.*, metapterygoid.	40.
7.	Ditto; hinder end of jaws of left side, outer aspect.—A Turonian zone; Cuxton. Harford Collection (B. M. no. P. 5673). *ag.*, articulo-angular; other letters as in fig. 6.	40.
8.	*Apateodus lanceolatus*, A. S. Woodward; portion of right palato-pterygoid arcade, outer aspect.—Zone of *Holaster subglobosus;* Dover. Bowerbank Collection (B. M. no. 39080). *ecpt.*, anterior end of ectopterygoid; *pl.*, palatine.	41.

All the figures of the natural size.



F. H. Michael del. et lith.

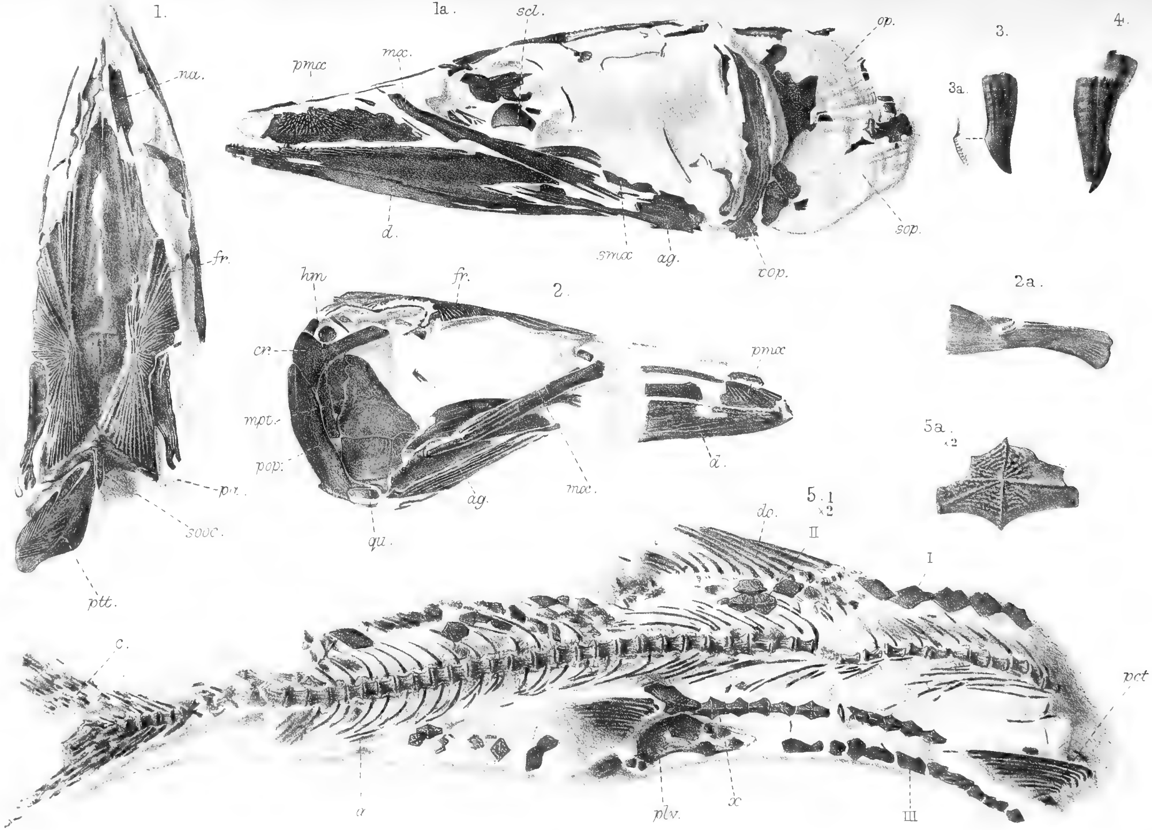
Mintern Bros imp.

Apateodus.

PLATE XII.

Fig.		Page.
1.	*Cimolichthys lewesiensis*, Leidy; head with opercular apparatus, upper aspect and (1 *a*) left lateral aspect.—English Chalk. Egerton Collection (B. M. no. P. 1811). *ag.*, articulo-angular; *d.*, dentary; *fr.*, frontal; *mx.*, maxilla; *na.*, nasal; *op.*, operculum; *pa.*, parietal; *pmx.*, premaxilla; *pop.*, preoperculum; *ptt.*, post-temporal; *scl.*, sclerotic; *smx.*, supramaxilla; *socc.*, supraoccipital; *sop.*, suboperculum.	45.
2.	Ditto; head, broken across rostrum, right lateral aspect.—A Turonian zone; Lewes. Enniskillen Collection (B. M. no. P. 5491). *cr.*, backwardly crushed crest of hyomandibular (*hm.*); *mpt.*, metapterygoid; *qu.*, quadrate; other letters as in fig. 1.	45.
	2 *a*. Left ceratohyal of same, inner aspect.	48.
3.	Ditto; barbed upper tooth, with part of crenulated hinder border enlarged (3 *a*).—Zone of *Holaster subglobosus;* Westwell, Charing, Kent. Harris Collection (B. M. no. P. 329).	46.
4.	Ditto; barbed upper tooth.—Chalk; Burham, Kent. B. M. no. 40143.	46.
5.	Ditto? (*Plinthophorus robustus*, Günther); slightly distorted trunk, right lateral aspect, one half nat. size, with a ventral scute (5 *a*) enlarged twice.—Zone of *Holaster subglobosus;* Folkestone. B. M. no. 38113. *a.*, anal fin; *c.*, caudal fin; *do.*, dorsal fin; *pct.*, pectoral fin; *plr.*, pelvic fin-support; *x.*, scute enlarged in fig. 5 *a*; I, II, III, rows of scutes.	48.

All the figures, except 3 *a*, 5, 5 *a*, of the natural size.



A. H. Searle del. et lith.

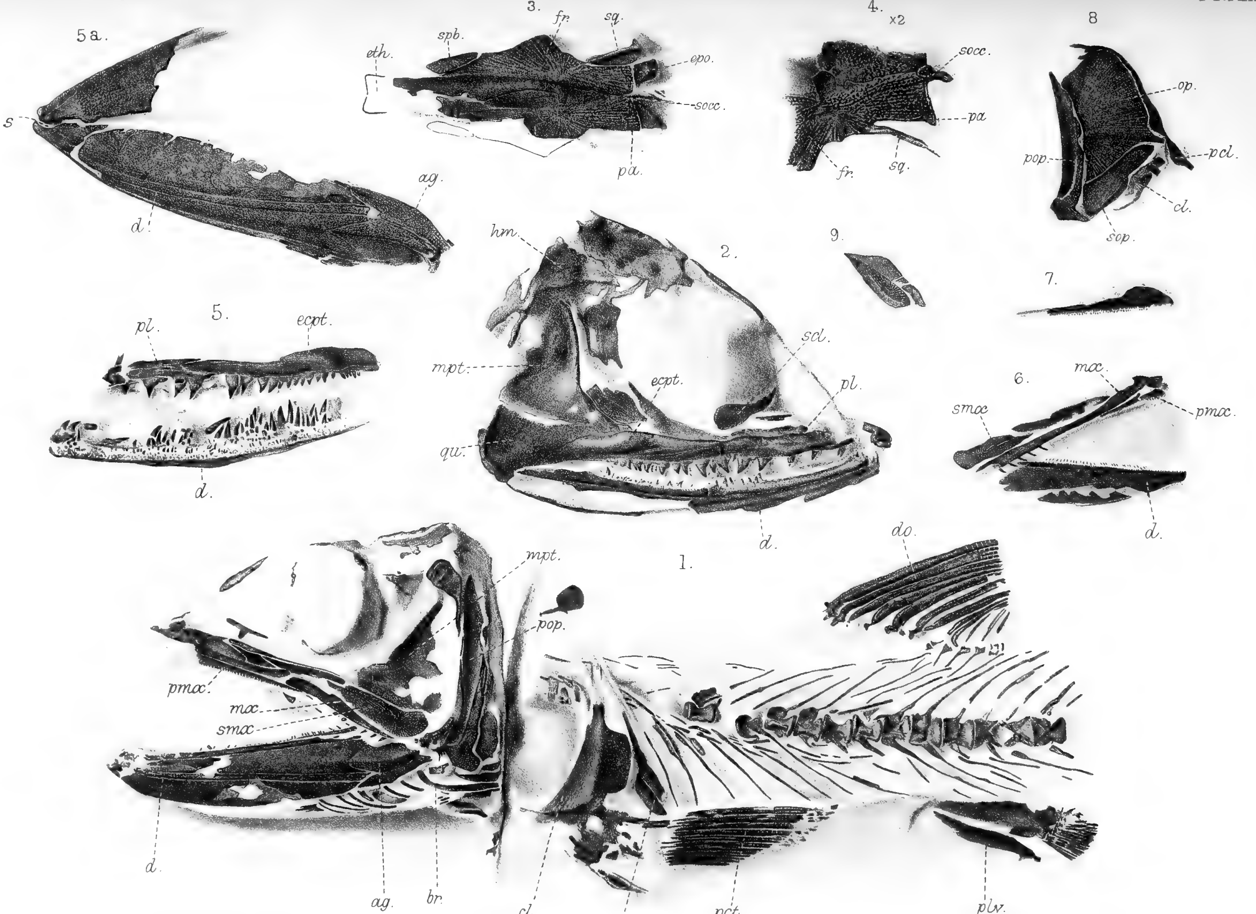
Mintern Bros. imp.

Cimolichthys.

PLATE XIII.

Fig.		Page.
1.	*Halec eupterygius* (Dixon); imperfect head and abdominal region, left lateral aspect.—A Turonian zone; near Maidstone. B. M. no. 32336. *ag.*, articulo-angular; *br.*, branchiostegal rays; *cl.*, clavicle; *d.*, dentary; *do.*, dorsal fin; *mpt.*, metapterygoid; *mx.*, maxilla; *pcl.*, post-clavicle; *pct.*, pectoral fin; *plv.*, pelvic fin-supports and portion of fin; *pmx.*, premaxilla; *pop.*, preoperculum; *smx.*, supramaxilla.	53.
2.	Ditto; imperfect head, right lateral aspect.—A Turonian zone; Lewes. Mantell Collection (B. M. no. 4285). *ecpt.*, ectopterygoid; *hm.*, hyomandibular; *pl.*, palatine; *qu.*, quadrate; *scl.*, sclerotic; other letters as in fig. 1.	51.
3.	Ditto; cranial roof, upper aspect.—Zone of *Holaster subglobosus*; Halling, Kent. Harford Collection (B. M. no. P. 5662). *epo.*, epiotic; *eth.*, restored outline of mesethmoid; *fr.*, frontal; *pa.*, parietal; *socc.*, supraoccipital; *spb.*, supraorbital; *sq.*, probably squamosal ridge.	51.
4.	Ditto; portion of hinder part of cranial roof, upper aspect, twice nat. size.—Probably zone of *Holaster subglobosus*; Burham, Kent. Enniskillen Collection (B. M. no. P. 4537). Letters as in fig. 3.	51.
5.	Ditto; remains of jaws, left lateral aspect, and imperfect mandible (5 *a*), inferior aspect.—English Chalk. B. M. no. P. 9252. *s.*, mandibular symphysis; other letters as in figs. 1, 2.	53.
6.	Ditto; remains of jaws of right side, outer aspect.—English Chalk. Enniskillen Collection (B. M. no. P. 3657). Letters as in fig. 1.	53.
7.	Ditto; left premaxilla, inner aspect.—Chalk; Brighton. Capron Collection (B. M. no. 49750).	53.
8.	Ditto; left opercular apparatus, outer aspect.—Probably from Burham. Mrs. Smith's Collection (B. M. no. 49111). *cl.*, clavicle; *op.*, operculum; *pcl.*, postclavicle; *pop.*, preoperculum; *sop.*, suboperculum.	53.
9.	Ditto; left post-temporal, outer aspect.—A Turonian zone; Lewes. Enniskillen Collection (B. M. no. P. 3657*a*).	54.

All the figures, except 4, of the natural size.



A. H. Searle del. et lith.

Halec.

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THE

PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

VOLUME FOR 1902.

LONDON:

MDCCCCII.

A MONOGRAPH

OF THE

CRETACEOUS LAMELLIBRANCHIA

OF

ENGLAND.

BY

HENRY WOODS, M.A.,

UNIVERSITY LECTURER IN PALÆOZOOLOGY, CAMBRIDGE.

PART IV.

PECTINIDÆ.

PAGES 145—196; PLATES XXVII—XXXVIII.

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1902.

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Family—PECTINIDÆ,[1] *Lamarck*.

Genus—Pecten, *Müller*, 1776.

(‘Prodr. Zool. Dan.,’ p. 248.)

Sub-genus—Syncyclonema, *F. B. Meek*, 1864.

(‘Check List of Invert. Foss. N. America, Cret. and Jur.,’ Smithson, Misc. Coll. 177, pp. 7, 31.)

Syncyclonema should probably be united with *Entolium*, as has been suggested by Philippi, since in the former the concentric ornamentation of the right valve is sometimes incompletely developed, and the ears have, in some cases, a more or less well-marked dorsal prolongation; on the other hand, in some forms of *Entolium* the dorsal prolongation of the ears is insignificant. *Syncyclonema* is the earlier of the two names. The type of *Entolium*[2] is *Pecten demissus*, Phillips; this has also been taken by Verrill[3] as the type of *Protamusium*.

Pecten (Syncyclonema) orbicularis, *Sowerby*, 1817. Plate XXVII; and Text-fig. 1.

1817.	Pecten orbicularis, *J. Sowerby*.	Min. Conch., vol. ii, p. 193, pl. clxxxvi.
1819.	— — *Lamarck*.	Anim. sans Vert., vol. vi, pt. 1, p. 182.
1822.	— laminosus, *G. Mantell*.	Foss. S. Downs, p. 128, pl. xxvi, figs. 8, 22.
1825.	— orbicularis, *Defrance*.	Dict. Sci. nat., vol. xxxviii, p. 252.

[1] Recent accounts of the classification of the Pectinidæ have been given by—A. E. Verrill, “A Study of the Pectinidæ, with a Revision of the Genera and Sub-genera,” ‘Trans. Connecticut Acad.,’ vol. x (1897), p. 41. F. Sacco, “Molluschi dei Terreni Terziarii del Piemonte e della Liguria;” pt. 24, “Pectinidæ,” 1897. W. H. Dall, “Tertiary Fauna of Florida,” ‘Trans. Wagner Free Inst. of Philadelphia,’ vol. iii, pt. 4 (1898), pp. 689—758. E. Philippi, “Beiträge zur Morphologie und Phylogenie der Lamellibranchier:” (1) “*Hinnites* und *Velopecten*,” ‘Zeitschr. der deutsch. geol. Gesellsch.,’ vol. l (1898), p. 597; (2) “Zur Stammesgeschichte der Pectiniden,” ibid., vol. lii (1900), p. 64. A. Locard, “Faune Malacologique Française,” xi, “Monographie des Espèces appartenant au Genre *Pecten*,” ‘Ann. Soc. Linn. de Lyon,’ vol xxxiv (1888), p. 133. C. Depéret and F. Roman, “Monographie des Pectinidés néogènes de l’Europe et des régions voisines,” ‘Mém. Soc. géol. de France (Paléont.),’ vol. x, pt. 1 (1902).

[2] Meek, “Geol. Survey of California,” ‘Geology,’ vol. i, Appendix B (1865), pp. 478, 479.

[3] ‘Trans. Connect. Acad.,’ vol. x (1897), p. 71.

? 1836. Pecten laminosus, *A. Goldfuss.* Petref. Germ., vol. ii, p. 76, pl. xcix, fig. 9.
— — orbicularis, *Lamarck.* Anim. sans Vert. (ed. 2, by Deshayes and Milne-Edwards), vol. vii, p. 159.
1839. — laminosus, *H. B. Geinitz.* Char. d. Schicht. u. Petref. des sächs. Kreidegeb., pt. 1, p. 23.
— — circularis, *Geinitz.* Ibid., p. 23.
1841. — orbicularis, *F. A. Römer.* Die Verstein. nord-deutsch. Kreidegeb., p. 49.
— — laminosus, *Römer.* Ibid., p. 49.
1843. — orbicularis, *H. B. Geinitz.* Die Verstein. von Kieslingswalda, p. 16.
1844. — — *A. d'Orbigny.* In X. Hommaire de Hell, Les Steppes de la Mer Caspienne, vol. iii, p. 439, pl. vi, figs. 18—20.
? 1845. — — *E. Forbes.* Quart. Journ. Geol. Soc., vol. i, p. 249.
1846. — — *A. E. Reuss.* Die Verstein. der böhm. Kreideformat., pt. 2, p. 27, pl. xli, figs. 18, 19.
— — laminosus, *Reuss.* Ibid., p. 27, pl. xxxix, fig. 5.
1847. — orbicularis, *A. d'Orbigny.* Pal. Franç. Terr. Crét., vol. iii, p. 597, pl. ccccxxxiii, figs. 14—16.
? — — laminosus, *J. Müller.* Petref. Aachen. Kreideformat., pt. 1, p. 31.
1848. — orbicularis, *H. G. Bronn.* Index Palæont., vol. i, p. 928.
1850. — — *H. B. Geinitz.* Das Quadersandst. oder Kreidegeb. in Deutschland, p. 180.
— — — *A. d'Orbigny.* Prodr. de Pal., vol. ii, p. 169.
? 1852. — — *R. Kner.* Denkschr. d. k. Akad. d. Wissensch. Math.-nat. Classe, vol. iii, p. 315.
1854. — — *J. Morris.* Cat. Brit. Foss., ed. 2, p. 177.
1855. — — *G. Cotteau.* Moll. Foss. de l'Yonne, p. 116.
1863. — — *A. v. Strombeck.* Zeitschr. d. deutsch. geol. Gesellsch., vol. xv, p. 108.
1868. — — *E. Eichwald.* Lethæa Rossica, vol. ii, p. 423, pl. xx, fig. 4.
1869. — sublaminosus, *E. Favre.* Moll. Foss. Craie de Lemberg, p. 143, pl. xiii, fig. 1.
1870. — orbicularis, *F. J. Pictet and G. Campiche.* Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 5), p. 206.
— — — *W. A. Ooster.* Protoz. Helvet., vol. ii, p. 57.
1871. — (Syncyclonema) orbicularis, *F. Stoliczka.* Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 428.
1872. — laminosus, *H. B. Geinitz.* Das Elbthalgeb. in Sachsen (Palæontographica, vol. xx, pt. 1), p. 192, pl. xliii, fig. 14.
1873. — opercularis, *W. Dames.* Zeitschr. d. deutsch. geol. Gesellsch., vol. xxv, p. 68; ibid, vol. xxvi, p. 763 (foot-note).
1874. — (Amusium) orbicularis, *Dames.* Ibid., vol. xxvi, p. 763.

1874. Pecten laminosus, *Dames.* Ibid., p. 764.
1876. — — *H. Deicke.* Die Tourtia von Mülheim a. d. Ruhr, p. 26.
1877. — — *A. Fritsch.* Stud. im Gebiete der böhm. Kreideformat.: II, Die Weissenberg. und Malnitz. Schicht., p. 136, fig. 126.
— — orbicularis, *G. Boehm.* Zeitschr. d. deutsch. geol. Gesellsch., vol. xxix, p. 233.
1881. — — *J. Kiesow.* Schrift. d. nat. Gesellsch. in Danzig, N. F., vol. v, p. 415.
1882. — cf. orbicularis, *R. Windmöller.* Jahrb. d. k. preussisch. geol. Landesanst. für 1881, p 20.
1883. — orbicularis, var. magnus, *W. Keeping.* Foss., etc., Neoc. Upware and Brickhill, p. 106, pl. v, fig. 1.
1885. — (Syncyclonema) orbicularis, *F. Nötling.* Die Fauna d. baltisch. Cenoman. (Palaeont Abhandl., vol. ii), p. 19, pl iii, figs. 4, 5.
— — — laminosus, *Nötling.* Ibid., p. 19, pl. iii, fig. 3.
? — Syncyclonema sublaminosa, *J. Böhm.* Verhandl. des nat. Vereins d. preussisch. Rheinl., vol. xlii, p. 83.
? 1889. Pecten laminosus, *E. Holzapfel.* Die Mollusk. Aachen. Kreide (Palæontographica, vol. xxxv), p. 231.
1893. — orbicularis, *R. Michael.* Zeitschr. d. deutsch. geol. Gesellsch., vol. xlv, p. 236.
— — laminosus, *Michael.* Ibid., p. 235.
? 1894. — orbicularis, *A. Hennig.* Geol. Fören. i Stockholm Förhandl., vol. xvi, p. 519.
1895. — Cottaldinus, *G. Maas.* Zeitschr. d. deutsch. geol. Gesellsch., vol. xlvii, p. 269.
1896. — orbicularis, var. Lohmanni, *A. Wollemann.* Ibid., vol. xlviii, p. 839, pl. xxi, fig. 1.
1897. — — *U. Söhle.* Geognost. Jahreshefte, N. J. (1896), p. 40, pl. iv, fig. 8.
— Syncyclonema orbicularis, *R. B. Newton.* Proc. Dorset Nat. Hist. and Antiq. Field Club, vol. xviii, p. 84, pl. iii, fig. 9.
1900. Pecten germanicus, *A. Wollemann.* Die Biv. u. Gastrop. d. deutsch. u. holländ. Neocoms (Abhandl. d. k. preussisch. geol. Land., N. F., pt. 31), p. 41, pl. viii, figs. 13–19.

Non 1827. Pecten orbicularis, *S. Nilsson.* Petrif. Suecana, p. 23, pl. x, fig. 12 (= *P. Nilssoni*, Goldf.).
— 1846. — — ?, *E. Forbes.* Trans. Geol. Soc., ser. 2, vol. vii, p 154 (= *Amusium sulcatellum*, Stol.).

Description.—Shell ovate or nearly orbicular, nearly equilateral; height a little greater than length; margins on each side of the umbo straightened, that on the posterior side being slightly longer than the corresponding anterior part. Valves

flattened, compressed near the straight margins; the left valve sometimes rather more convex than the right. Ears rather small, nearly equal, the anterior slightly larger than the posterior, both often slightly produced dorsally; external margins usually curving, sometimes nearly straight; those of the posterior ears somewhat more oblique than those of the anterior. Surface of ears smooth or with growth-lines, and occasionally radial striæ. Umbones sharp; apical angle varying from 99° to 115°, average 106°. No byssal sinus. Hinge similar to *Amusium.*

Right valve ornamented with broad and usually well-marked concentric ridges and furrows, varying in number. Ridges flat, and, in well-preserved specimens, with a ventral laminar portion projecting over the next furrow; the furrows are narrower or absent near the antero- and postero-dorsal margins. The ridges are ornamented with fine concentric grooves, and with finer radial striæ, the latter being seen best near the antero- and postero-dorsal margins.

Left valve appears almost or quite smooth to the naked eye, but with a lens is seen to be ornamented with numerous fine concentric grooves, and sometimes with fine radial striæ.

Measurements :

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	
Length .	25·5	24	22	15·5	13·5	21·5	31	47	40	39·5	55	30	26	24	15·5	44	73	22	13	69	34	31	23·5	mm
Height .	27·5	26	25	17	15·5	25	34	50	43	42	56	33	28	26	17	47	76	23	14	70	36	33·5	26	„

(1—4) Tealby Limestone.
(5) Folkestone Beds, Folkestone.
(6, 7) Greensand (Chert Beds), Haldon.
(8—11) Upper Greensand, Ventnor.
(12, 13) „ „ Warminster.
(14—16) Gault, Folkestone.
(17—19) Chalk Marl, Folkestone.
(20, 21) Chalk Marl, Burwell.
(22, 23) Totternhoe Stone, Burwell.

Affinities.—*P. germanicus*, Wollemann, from the Neocomian of Brunswick, appears to be inseparable from this species. The characters regarded as distinctive by Dr. Wollemann, such as the fine concentric striæ on the left valve, the more laminar character of the concentric ribs on the right, and their radial striæ, are also found in many specimens of *P. orbicularis;* their presence and distinctness depend mainly on the state of preservation of the specimens. Dr. Wollemann has examined a specimen from the Tealby Limestone (similar to Pl. XXVII, figs. 1, 2), and informs me that it is undoubtedly identical with his *P. germanicus;* he has also kindly sent me specimens of the latter from near Brunswick, and they seem to be quite inseparable from *P. orbicularis.* The difference in horizon is mentioned by Dr. Wollemann as giving some support to his view that the Neocomian form is distinct, but since *P. orbicularis* ranges, without a break, from the zone of *B. brunsvicensis* to the zone of *Holaster subglobosus*, we must rather regard the continuous distribution as favourable to the identity of the earlier and later forms.

P. orbicularis, var. *magnus*, Keeping, from Upware, is a large variety of this species, and is similar to a form found in the Chalk Marl (Text-fig. 1). In the

specimens which I have seen, the concentric ornament on the right valve is indistinct, owing to the imperfect preservation of the surface of the shell, but in several cases the fine concentric grooves are clearly shown on the left valve.

Pecten Darius, d'Orbigny,[1] from the Albian, is a closely allied form, but at present is known only by the brief description in the 'Prodrome.' The form from the Gault of Cosne, described by De Loriol[2] as *P. Darius*, appears to differ from *P. orbicularis* in the inequality of its ears; the figures do not show the character of the ornamentation satisfactorily. *Amusium sulcatellum*, Stoliczka,[3] and *P. concentrice-sulcatus*, Müller,[4] appear to be closely allied to *P. orbicularis.*

The Senonian specimens described by Goldfuss, Holzapfel, etc., as *P. laminosus*, Goldfuss, and by Favre and Böhm as *P. sublaminosus*, seem to agree with those forms of *P. orbicularis* which have more numerous ribs than usual, and particularly with some examples from the Warminster Greensand and the Chloritic Marl of Maiden Bradley. Professor Holzapfel has kindly sent me eight specimens from the Aachen Greensand, but it is difficult to compare them satisfactorily with English examples owing to their different mode of preservation. There does not, however, appear to be sufficient reason to regard them as distinct from the Cenomanian forms of *P. orbicularis.* The ears in the example figured by Goldfuss are larger than is usual in *P. orbicularis.*

P. membranaceus, Nilsson,[5] is similar in form to *P. orbicularis*, but has the concentric ornamentation very fine, so that the shell appears to be almost smooth. *P. Nilssoni,* Goldfuss,[6] is also distinguished by being nearly smooth, and (judging from Goldfuss' fig. 8 *b*) is still further separated from this group by its deep byssal sinus.

P. nummularis, Fischer de Waldheim,[7] is a closely allied form, but without seeing a series of specimens I am unable to make a comparison.

P. (*Amusium*) *balticus*, Dames,[8] is probably identical with *P. orbicularis.*

[1] 'Prodr. de Pal.,' vol. ii (1850), p. 139.

[2] "Faune du Gault de Cosne," 'Mém. Soc. Pal. Suisse,' vol. ix, 1882, p. 84, pl. x, fig. 6.

[3] 'Palæont. Indica, Cret. Fauna S. India,' vol. iii (1871), p. 436, pl. xxxi, figs. 12, 17.

[4] 'Mollusk. Untersenon von Braunschweig u. Ilsede' (1898), p. 34, pl. v, fig. 9.

[5] 'Petrif. Suec.' (1827), p. 23, pl. ix, fig. 16 (lower figure). See also Hennig, Holzapfel, Zittel, Geinitz, Goldfuss, etc.

[6] 'Petref. Germ.,' vol. ii (1836), p. 76, pl. xcix, fig. 8.

[7] Fischer de Waldheim, 'Bull. Soc. Imp. Nat. de Moscou,' vol. xvi (1843), p. 135, pl. v, fig. 4; d'Orbigny, in Murchison, de Verneuil, and Keyserling, 'Géol. de la Russie,' vol. ii (1845), p. 475, pl. xli, figs. 20—23, and figs. 16—19 (*P. demissus*); d'Orbigny, 'Prodr. de Pal.,' vol. i (1849), p. 373; Trautschold, 'Bull. Soc. Imp. Nat. de Moscou,' vol. xxxviii (1865), p. 23, pl. iii, fig. 2; Nikitin, "Les Vestiges de la Période Crét. dans la Russ. Centrale," 'Mem. Com. Géol.,' vol. v, 1888, p. 73; *P. demissus*, Trautschold, 'Bull. Soc. Imp. Nat. de Moscou,' vol. xxxiv (1861), p. 268, pl. vii, fig. 4.

[8] 'Zeitschr. d. deutsch. geol. Gesellsch.,' vol. xxvi (1874), p. 762, pl. xxi, fig. 1. Nötling, "Baltischen Cenoman.," 'Palaeont. Abhandl.,' vol. ii, p. 17, pl. ii, fig. 7.

Remarks.—The appearance of the shell differs considerably according to the state of preservation; the *fine* concentric grooves on the right valve are seen chiefly when the outermost layer of the shell has been removed; when a thicker layer has disappeared this valve may become almost smooth.

This is one of the commonest and most widely distributed of the Cretaceous Pectens; it varies considerably in size, in proportions, in the number of concentric ribs, and also to some extent in convexity. Some of the varieties are more abundant at certain horizons than elsewhere, but are seldom, if ever, limited to one level, and are doubtless accounted for by the varying conditions under which the deposits were laid down. Some of these varieties are here briefly noticed.

1. *Tealby Limestone* (zone of *Bel. brunsvicensis*).—The forms found at this horizon never reach a large size (Pl. XXVII, figs. 1, 2), and on the average are smaller than those found in the Cenomanian; they are also slightly higher in proportion to their length, and often rather more convex. The number of concentric ribs is not so great as in many Upper Greensand and Cenomanian forms. Near the umbo there is usually seen a fairly large, smooth portion of the shell without ribs, which at first sight appears to be a distinguishing feature of the forms from this horizon. But the examination of a large series of specimens shows that this is due to imperfect preservation; the same feature has been noticed by Dr. Wollemann in Brunswick specimens. The size of this smooth area varies very considerably in different specimens, and occasionally nearly all the concentric ribs have disappeared; moreover, an identical smooth portion is sometimes seen in specimens from the Gault and Chalk Marl.

2. *Folkestone Beds.*—Forms very similar to those from the Tealby Limestone and of about the same size occur in the Folkestone Beds of Folkestone, but do not appear to be numerous. The number of ribs is sometimes greater, sometimes less than in the Tealby specimens.

3. *Gault.*—The forms in the Gault (Pl. XXVII, fig. 3) are, on the average, of about the same size as the Tealby specimens, but some larger examples also occur; they sometimes possess rather more numerous ribs, and in some cases the valves are quite as convex as in the Tealby forms, but usually rather less.

4. *Upper Greensand.*—The forms from Ventnor are noteworthy for the large size which they reach; the number of concentric ribs is variable, and on the largest specimens the later part of the valve (Pl. XXVII, fig. 7*a*) is smooth and without ribs, and in the ribbed part two distinct stages may sometimes be noticed, an earlier with close-set ribs, a later with more widely separated ribs (Pl. XXVII, figs. 8, 9). Sometimes the grooves are widely spaced and the ribs broad (fig. 9*a*).

P. orbicularis seems to be rare at Blackdown, and the forms seen are rather small, with numerous ribs. The examples from the Chert Beds of Haldon (Pl. XXVII, fig. 4), of which there is a good series in the Exeter Museum, have the

ears much larger than usual, also a smaller apical angle, and straight antero- and postero-dorsal margins; the shell is rather high in proportion, and the ribs are numerous. Since all the Haldon specimens agree in these respects, and are readily distinguishable from those found elsewhere, they may be regarded as a local variety, and named *P. orbicularis*, var. *haldonensis* : this variety resembles the form from the Cenomanian of Bavaria figured by Söhle (1897). The forms found in the Upper Greensand of Warminster are rather larger than most of those in the Gault and Lower Cretaceous, and often have numerous ribs.

5. *Cenomanian.*—Small forms, with a variable number of ribs, occur commonly in the Chalk Marl, and rarely also a very large variety, sometimes reaching 76 mm. in height (Text-fig. 1). In the *H. subglobosus* zone the average size is rather

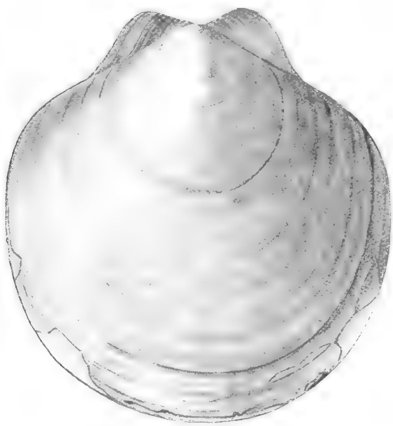


FIG. 1.—*Pecten (Syncyclonema) orbicularis*, Sow. Chalk Marl, Folkestone. Woodwardian Museum. Natural size.

larger than in Gault and Lower Cretaceous, but no forms as large as those in the Upper Greensand mentioned above have been seen. The number of ribs is variable.

Types.—The type, from the Upper Greensand of Devizes, appears to have been lost, and the same is the case with the types of *P. laminosus* from the Chalk Marl of Hamsey and Stoneham.

Distribution.—Folkestone Beds of Folkestone. Lower Greensand of Upware. Spilsby Sandstone of Donnington and Spilsby. Claxby Ironstone of Benniworth Haven. Tealby Limestone (zone of *B. brunsvicensis*) of North Willingham and Claxby. Speeton Series (same zone) of Speeton (*fide* Lamplugh).

Also recorded in the Geological Survey Memoirs from the *Perna*-bed of Ather-

field and Sandown; the Ferruginous Sands of Shanklin; the Carstone of Bonchurch, etc.; the Hythe Beds of Hythe, Maidstone, Godalming, and Pulborough; and the Sandgate Beds of Sandgate and Parham. I have not seen the specimens on which these records are based.

Gault of Folkestone (zones i—iii, ix—xi), and Black Ven. Zone of *H. interruptus* of Okeford Fitzpaine. Recorded by the Geological Survey from the Gault of Compton Bay, Culver, Blackgang, Niton, and Bonchurch, and from the Red Limestone of Hunstanton. Cambridge Greensand (derived from the Gault). Upper Greensand (zone of *Schlœnbachia rostrata*) of Blackdown, Devizes, Ventnor, Selborne, and the Devon coast. Upper Greensand (zone of *Pecten asper*) of Haldon, Warminster, Ventnor, and Niton.

Chloritic Marl of Maiden Bradley and Ventnor. Chalk Marl of Folkestone, Hamsey, Blue Bell Hill (Burham), Burwell, Madingley, and Hauxton. Cenomanian of Wilmington. Lower Chalk (? Chalk Marl) of Stoke Ferry. Totternhoe Stone of Cherry Hinton, Fulbourn, and Burwell. Zone of *H. subglobosus* of Cherry Hinton.

PECTEN, sp., cf. NILSSONI, *Goldfuss*, 1836.

A species, apparently belonging to this group, has been found by Mr. R. M. Brydone in the Chalk of Trimingham; it has a smooth, or nearly smooth, thin shell, with nearly equal ears, and seems to agree with *P. Nilssoni*, Goldfuss,[1] but I am unable to say whether it possesses a byssal sinus as is shown in the figures of Goldfuss and Ravn. It also resembles *P. membranaceus*, Nilsson (see p. 149), but appears to have been proportionately longer, and has consequently a larger apical angle and smaller ears. Only three incomplete specimens have been seen, the largest having a length of about 53 mm.

Sub-genus—CAMPTONECTES (*Agassiz* MS.), *F. B. Meek*, 1864.

('Check List of Invert. Foss. N. America, Cret. and Jur.,' Smithson, Misc. Coll. 177, pp. 28, 39.)

PECTEN (CAMPTONECTES) CINCTUS, *Sowerby*, 1822. Plate XXVIII; and Text-fig. 2.

1822. PECTEN CINCTUS, *J. Sowerby*, Min. Conch., vol. iv, p. 96, pl. ccclxxi.
1825. — — *Defrance*. Dict. Sci. nat., vol. xxxviii, p. 254.

[1] Müller (1827), p. 23, pl. x, fig. 12. Goldfuss, vol. ii (1836), p. 76, pl. xcix, fig. 8. Hennig (1897), p. 45, pl. iii, figs. 18, 19. Vogel (1895), p. 21, pl. i, fig. 17. Ravn (1902), p. 9, pl. ii, figs. 3—5. See also Römer (1841), Reuss (1846), Favre (1869), Geinitz (1872), Brauns (1876), Fritsch (1877–97), Behrens (1878), Griepenkerl (1889), Stolley (1892), Leonhard (1897).

1839. PECTEN CRASSITESTA, *F. A. Römer.* Verstein. nord-deutsch. Oolith.-geb. Nachtrag, p. 27.
1841. — CINCTUS, *F. A. Römer.* Die Verstein. nord-deutsch. Kreidegeb., p. 50.
1846. — IMPERIALIS, *A. Keyserling.* Petschoraland, p. 295, pl. xv.
1847. — CRASSITESTA, *A. d'Orbigny.* Pal. Franç. Terr. Crét., vol. iii, p. 584, pl. ccccxxx, figs. 1—3.
? 1854. — CINCTUS, *J. Morris.* Cat. Brit. Foss., ed. 2, p. 176 (not from the locality and horizon given).
? — — CRASSITESTA, *Morris.* Ibid., p. 176.
1868. — — *E. Eichwald.* Lethæa Rossica, vol. ii, p. 427.
1870. — — *F. J. Pictet and G. Campiche.* Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 5), p. 212.
1871. — (PSEUDAMUSIUM) CRASSITESTA, *F. Stoliczka.* Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 428.
1884. — CRASSITESTA, *O. Weerth.* Die Fauna des Neocom. im Teutoburg. Walde (Palaeont. Abhandl., vol. ii), p. 53.
— — ROEMERI, *Weerth.* Ibid., p. 54.
1895. — (SYNCYCLONEMA) CRASSITESTA, *F. Vogel.* Holländ. Kreide, p. 54.
— — CRASSITESTA, *G. Maas.* Zeitschr. d. deutsch. geol. Gesellsch., vol. xlvii, p. 299.
1896. — — *A. Wollemann.* Ibid., vol. xlviii, p. 838.
1899. — — *G. Maas.* Ibid., vol. li, p. 249.
1900. — — *A. Wollemann.* Die Biv. u. Gastrop. d. deutsch. u. holländ. Neocoms (Abhandl. d. k. preussisch. geol. Land., N. F., pt. 31), p. 39.

Description.—Shell very large, stout, rather convex, oval or nearly circular, almost equilateral, length sometimes a little greater than height, sometimes a little less. Umbo pointed, with the margins on each side straight or slightly concave. Apical angle from 133° to 144° in the longer forms; from 120° to 127° in the shorter and higher forms. Ears long and low, unequal.

Right valve moderately convex, with a nearly smooth surface; ornamented with very regular concentric linear grooves between which are flat interspaces, the ventral edges of which are sometimes produced as laminæ over the grooves. The interspaces are crossed by numerous radial striæ, which sometimes extend only part of the distance from one concentric groove to the next; also faint concentric ridges are sometimes seen. Anterior ear larger than posterior, with a well-marked byssal sinus, ornamented with close-set sinuous ridges. Posterior ear with the outer angle rectangular or slightly obtuse, ornamented with ridges crossed by radial striæ.

Left valve more convex than the right, with similar ornamentation, but having the concentric grooves more distinct, the laminæ often more prominent, and the

radial striæ usually less distinct and sometimes absent except near the umbo. Ears slightly unequal, with ridges and radial grooves.

Measurements :

	A							B							
	(1)	(2)	(3)	(4)	(5)	(6)		(1)	(2)	(3)	(4)	(5)	(6)	(7)	
Length .	57	118	118	120	132	191	...	52	150	191	195	204	212	231	mm.
Height .	62	125	129	127	145	207	...	52	145	179	184	192	201	226	,,

A. The higher and shorter forms. (1) Tealby Limestone: (2—6) Claxby Ironstone.
B. The lower and longer forms. (1) Tealby Limestone: (2—7) Claxby Ironstone.

Affinities.—Goldfuss' *P. circularis*[1] was regarded by Römer and Bronn as identical with *P. crassitesta*, Römer; subsequently both were considered by Römer as synonyms of *P. cinctus*, Sowerby. The example figured by Goldfuss is stated by him to have come from the Greensand of Dorsetshire; but no species of this type appears to have been found in the Greensand of that district, whereas the similar form *P. lamellosus*, Sowerby, from the Portlandian, is common there, and Goldfuss' figure agrees more closely with that than with *P. cinctus:* this view was evidently held by Morris, since he gives *P. circularis* as a synonym of *P. lamellosus. P. lamellosus*, Sowerby,[2] is undoubtedly closely allied to *P. cinctus;* the ornamentation is practically identical in both, for although the radial striæ on the former are usually less distinct in specimens from the Portland Limestone, they are quite as well-marked in specimens from the Portland Clay as in *P. cinctus. P. lamellosus* may, however, be distinguished by its greater obliquity, smaller apical angle, and proportionately higher ears (especially the anterior). The shell never attains the same size as *P. cinctus*, its average being much less; the height appears to be nearly always greater than the length.

Remarks.—There are two forms of this species which differ in the proportions of length and height, as will be seen from the figures, and from the measurements (A and B) given above. In one (A) the height is greater than the length, and the valves are oval in outline, with a smaller apical angle and more elevated ears (Text-fig. 2). The right valve is rather more convex than in the other form. This form (A) was figured by Sowerby as *P. cinctus.* In the other form (B) the length is greater than the height, and the valves are more nearly circular in outline, with a larger apical angle and lower ears. The convexity of the valves is less, and the anterior and posterior parts are more compressed (Pl. XXVIII). This form was figured by d'Orbigny as *P. crassitesta.*

Since the forms A and B agree in all the details of ornamentation, and also

[1] 'Petref. Germ.,' vol. ii (1836), p. 76, pl. xcix, fig. 10.

[2] 'Min. Conch.,' vol. iii (1819), p. 67, pl. ccxxxix. See also de Loriol and Pellat, "Mon. de l'étage Portlandien de Boulogne-sur-Mer" ('Mém. Soc. Phys. et d'Hist. nat. de Genève,' vol. xix, 1866), p. 103, pl. x, fig. 4.

occur on the same geological horizons, and since each shows some variation in the proportions of length and height, there seems no reason to regard them as more than varieties of one species.

The concentric grooves are generally more widely separated in the specimens from the Speeton Clay than in those which come from the Claxby Ironstone.

This species has usually been known on the Continent as *P. crassitesta*, owing, no doubt, to the fact that the type of *P. cinctus* came from the Drift, and its true horizon was for some time thought to be Middle Jurassic; also to the fact of its

Fig. 2.—*Pecten (Camptonectes) cinctus*, Sow. Claxby Ironstone, Claxby. Woodwardian Museum. The higher and shorter form of the species. × $\frac{2}{3}$.

being the form with a higher shell, which is rather less common than the other variety.

Type.—In the British Museum; from the Drift—probably derived from the Claxby Ironstone.

Distribution.—Claxby Ironstone (zone of *Bel. lateralis*) of Claxby, North Willingham, Tealby, Donnington. Tealby Limestone (zone of *Bel. brunsvicensis*) of Claxby. Speeton Series (zone of *Bel. jaculum*, D 1, D 4, D 5) of Speeton.

Pecten (Camptonectes) Cottaldinus, *d'Orbigny*, 1847. Plate XXIX, figs, 1, 2 *a*, *b*, 3 *a*, *b*.

1845.	Pecten circularis, *E. Forbes.*		Quart. Journ. Geol. Soc., vol. i, p. 249 (*non* Goldfuss).
1847.	—	Cottaldinus, *A. d'Orbigny.*	Pal. Franç. Terr. Crét., vol. iii, p. 590, pl. ccccxxxi, figs. 7—11.
1850.	—	— —	Prodr. de Pal., vol. ii, p. 83.
1855.	—	— *G. Cotteau.*	Moll. Foss. de l'Yonne, p. 115.
1861.	—	— *P. de Loriol.*	Anim. Invert. Foss. Mt. Salève, p. 103, pl. xiii, fig. 3.
1868.	—	— *F. J. Pictet.*	Mélanges Paléont., pt. 4, p. 261, pl. xl, figs. 6, 7.
—	—	— *E. Eichwald.*	Lethæa Rossica, vol. ii, p. 431.
1870.	—	— *F. J. Pictet and G. Campiche.*	Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 5), pp. 197, 212, pl. clxvii, fig. 3.
? 1871.	—	— *W. A. Ooster.*	Protozoe Helvetica, vol. ii, pp. 105, 125, 141.
—	—	(Syncyclonema) Cottaldinus, *F. Stoliczka.*	Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 428.
1900.	—	Cottaldinus, *G. Müller.*	Verstein. d. Jura u. d. Kreide. In W. Bornhardt, Zur Oberflächen u. Geol. Deutsch - Afrikas (Deutsch - Ost-Afrika, vol. vii), p. 551.
Non 1895.	—	— *G. Maas.*	Zeitschr. d. deutsch. geol. Gesellsch., vol. xlvii, p. 269.

Description.—Shell ovate, rather higher than long, inequilateral; antero-dorsal margin slightly concave, and longer than the postero-dorsal, which is slightly convex. Convexity of valves small. Ears very unequal.

Right valve slightly convex; surface almost smooth, ornamented with numerous fine, regular, concentric grooves, which become more closely placed in passing from the umbo to the margin of the valve. The interspaces are flat and sometimes produced as slightly projecting laminæ next the concentric grooves. Near the umbo the interspaces are crossed by very fine, close-set radial striæ. Anterior ear large, produced, with a very deep byssal sinus, and a sulcus near the junction of the ear and valve; surface with many concentric narrow ridges. Posterior ear small, triangular, outer angle slightly obtuse, with concentric ornament.

Left valve moderately convex, with ornamentation similar to that of the right, but the concentric grooves are rather more distinct and not so close together; the radial striæ are more distinct and cover a larger part[1] of the valve. Anterior ear large, triangular, outer angle about 90°, height nearly or quite equal to length, with concentric ridges and radial striæ. Posterior ear much smaller and lower.

Measurements:

	(1)	(2)	(3)	(4)	(5)	(6)	
Length	35·5	45	49	53	57	76	mm.
Height	37	49	54	56	60	78·5	,,

(1—5) *Perna*-bed of Atherfield.
(6) Lower Greensand of Whale Chine.

Affinities.—This species is allied to *P. cinctus*, but differs in being less convex, higher than long, distinctly inequilateral, smaller, in having the concentric grooves, and usually also the radial striæ closer together, the ears more unequal, and the byssal sinus deeper.

Remarks.—A few small specimens (10 to 17 mm. long) from the Atherfield Beds of East Shalford, in the Meÿer Collection, may be young examples of *P. Cottaldinus*, but they also closely resemble *P. Greppini*, Pictet and Renevier.[2]

Types.—D'Orbigny's specimens came from the Neocomian of Auxerre, etc. The specimen referred to *P. circularis* by Forbes is in the Museum of the Geological Society (No. 2030).

Distribution.—*Perna*-bed of Atherfield. Lower Greensand (either *Scaphites* or Lower *Crioceras* Groups of Fitton) of Whale Chine. Recorded by Topley (1875) from the Atherfield Beds of Peasmarsh and Shalford.

PECTEN (CAMPTONECTES) STRIATO-PUNCTATUS, *Römer*, 1839. Plate XXIX, figs. 4 *a*, *b*, 5, 6.

1839.	PECTEN STRIATO-PUNCTATUS, *F. A. Römer.*	Die Verstein. d. nord-deutsch. Oolith.-geb. Nachtrag., p. 27.
1841.	— — —	Die Verstein. d. nord-deutsch. Kreidegeb., p. 50.
1847.	— — *A. d'Orbigny.*	Pal. Franç. Terr. Crét., vol. iii, p. 592, pl. ccccxxxii, figs. 4—7.
1850.	— — —	Prodr. de. Pal., vol. ii, pp. 83, 119.

[1] Perhaps the whole in perfectly preserved specimens.

[2] 'Foss. Terr. Aptien de la Perte du Rhone, etc.' (1858), p. 134, pl. xix, fig. 4. Pictet and Campiche, 'Terr. Crét. de Ste. Croix' (1870), p. 198.

1854. Pecten striato-punctatus, *J. Morris.* Cat. Brit. Foss., ed. 2, p. 177.
1868. — arzierensis, *P. de Loriol.* Valangien d'Arzier, p. 47, pl. iv, figs. 3—5.
1870. — striato-punctatus, *F. J. Pictet and G. Campiche.* Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 5), pp. 196, 211, pl. clxxi, figs. 4, 5.
— — arzierensis, *Pictet and Campiche.* Ibid., pp. 195, 211, pl. clxxi, fig. 3.
1871. — (Camptonectes) striato-punctatus, *F. Stoliczka.* Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 428.
1877. — striato-punctatus, *G. Böhm.* Zeitschr. d. deutsch. geol. Gesellsch., vol. xxix, p. 233.
1884. — — *O. Weerth.* Die Fauna des Neocom. im Teutoburg. Walde (Palaeont. Abhandl., vol. ii), p. 53.
1888. — arzierensis, *S. Nikitin.* Les Vest. de la Pér. Crét. dans la Russ. centrale (Mém. Com. Géol., vol. v), p. 73, pl. ii, fig. 12.
1889. — lens, var. morini, *G. W. Lamplugh.* Quart. Journ. Geol. Soc., vol. xlv, p. 615.
1895. — (Camptonectes) striato-punctatus, *F. Vogel.* Holländ. Kreide., p. 54.
1896. — striato-punctatus, *A. Wollemann.* Zeitschr. d. deutsch. geol. Gesellsch., vol. xlviii, p. 840.
1900. — — — Die Biv. u. Gastrop. d. deutsch. u. holländ. Neocoms (Abhandl. d. k. preussisch. geol. Land., N. F., pt. 31), p. 49.
? 1900. — — *G. Müller.* Verstein. d. Jura u. d. Kreide. In W. Bornhardt, Zur Oberflächen u. Geol. Deutsch-Afrikas (Deutsch-Ost-Afrika, vol. vii), p. 550, pl. xxiv, fig. 7.

Description.—Shell ovate, a little higher than long, nearly equilateral, convexity small, margins rounded, dorsal portion pointed. Ears unequal.

Right valve flattened, anterior ear with a deep sinus. Left valve rather more convex, anterior ear with the outer angle nearly rectangular, posterior ear with obtuse outer angle.

Both valves ornamented with numerous flattened radial ribs, which curve outwards from the median part of the valves, and sometimes bifurcate, or have new ribs intercalated. Ribs separated by narrow, sharply marked punctate grooves. At intervals a few distinct growth-lines occur. Ears with radial ribs crossed by concentric growth-ridges.

Measurements :

	(1)	(2)	(3)	(4)
Length .	36 .	25 .	22 .	15 mm.
Height .	40 .	27 .	26 .	19 ,,

(1) *B. lateralis* zone, Speeton.
(2, 3) *B. jaculum* zone, Speeton.
(4) Claxby Ironstone, Benniworth Haven.

These measurements are approximate only, on account of the imperfection of the specimens. Considerably larger examples than (4) occur in the Claxby Ironstone.

Affinities.—I have seen only a few specimens of this species, and most of them are very imperfect, consequently I am unable to make a detailed comparison with allied forms. The species which appears to approach most nearly *P. striato-punctatus* is *P. Morini*, de Loriol;[1] it is found in the Portlandian of Swindon, Hartwell, etc., and seems to differ from *P. striato-punctatus* in being less equilateral, owing to the greater proportionate length and inward curvature of the antero-dorsal margin; the ribs are also, on the average, more numerous and closer together, but vary somewhat in this respect.

P. virgatus, Nilsson, and *P. curvatus*, Geinitz (see below), are also related to *P. striato-punctatus.*

Remarks.—Römer figured no examples of this species, but erroneously referred to Goldfuss' figure of a Jurassic form (*P. lens*). A small form found rarely in the Gault of Folkestone is perhaps referable to *P. striato-punctatus.*

Types.—From the Hils-conglomerate and Hils-clay of Schandelah, Schoppenstedt, and Elligser Brink. D'Orbigny's specimens were obtained from the Aptian of St. Dizier (Haute Marne).

Distribution.—Speeton Clay (zones of *B. lateralis*, D 1, and of *B. jaculum*, C 11) of Speeton. Claxby Ironstone (zone of *Bel. lateralis*) of Benniworth Haven. ? Upper Gault (zone viii) of Folkestone.

Recorded by Topley (1875) from the Atherfield Beds of Peasmarsh and East Shalford, and from the Folkestone Beds of Folkestone. Recorded by Morris from the Lower Greensand of Folkestone.

PECTEN (CAMPTONECTES) CURVATUS, *Geinitz*, 1843. Plate XXIX, figs. 7 *a*, *b*; Plate XXXVII, fig. 16.

1833. PECTEN ARCUATUS, *A. Goldfuss.* Petref. Germ., vol. ii, p. 50, pl. xci, fig. 6 (*non* Nilsson).
? 1841. — — *F. A. Römer.* Die Verstein. d. nord-deutsch. Kreidegeb., p. 51.

[1] De Loriol and Pellat, "Portlandien de Boulogne-sur-Mer" ('Mém. Soc. Phys. et d'Hist. nat. Genève,' vol. xix, 1866), p. 107, pl. x, fig. 6.

1842. Pecten striato-punctatus, *H. B. Geinitz.* Char. d. Schicht. u. Petref. des sächs.-böhm. Kreidegeb., pt. 3, p. 83.

? 1843. — curvatus, *H. B. Geinitz.* Die Verstein. von Kieslingswalda, p. 16, pl. iii, fig. 13.

1846. — divaricatus, *A. E. Reuss.* Die Verstein. der böhm. Kreideformat., pt. 2, p. 28, pl. xxxix, fig. 6.

? — arcuatus, *Reuss.* Ibid., p. 27, pl. xxxix, fig. 7.

— curvatus, *H. B. Geinitz.* Grundr. der Verstein., p. 468.

? 1847. — arcuatus, *J. Müller.* Petref. der Aachen. Kreidef., pt. 1, p. 32.

— — virgatus, *A. d'Orbigny.* Pal. Franç. Terr. Crét., vol. iii, p. 602, pl. ccccxxxiv, figs. 7—10.

1848. — curvatus, *H. G. Bronn.* Index Palæont., vol. i, p. 922.

1850. — virgatus et curvatus, *H. B. Geinitz.* Das Quadersandst. oder Kreidegeb in Deutschland, p. 180.

? — — curvatus, *A. d'Orbigny.* Prodr. de Pal., vol. ii, p. 197.

? — — divaricatus, *A. d'Orbigny.* Ibid , p. 252.

? 1870. — virgatus, *F. Römer.* Geol. von Oberschles., p. 333.

— — curvatus, *F. J. Pictet and G. Campiche.* Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 5), p. 217.

1872. — — *H. B. Geinitz.* Das Elbthalgeb. in Sachsen (Palæontographica, vol. xx, pt. 1), p. 193, pl. xliii, fig. 15. ; pt. 2, p. 33, pl. x, fig. 1.

? 1876. — (Camptonectes) curvatus, *D. Brauns.* Zeitschr. f. d. gesammt. Naturwissensch., vol. xlvi, p. 390.

? 1877. — curvatus, *A. Fritsch.* Stud. im Gebiete der böhm. Kreideformat.: II, Die Weissenberg. und Malnitz. Schicht., p. 136, fig. 127.

? 1882. — virgatus, *H. Schröder.* Zeitschr. d. deutsch. goel. Gesellsch., vol. xxxiv, p. 270.

? 1883. — curvatus, *A. Fritsch.* Stud. im Gebiete der böhm. Kreideformat.: III, Die Iserschicht., p. 116.

1885. — (Camptonectes) divaricatus, *F. Nötling.* Die Fauna d. baltisch. Cenoman. (Palaeont. Abhandl., vol. ii), p. 17, pl. ii, fig. 6.

? Camptonectes curvatus, *J. Böhm.* Verhandl. des naturhist. Vereins d. Rheinl., vol. xlii, p. 78.

? 1887. Pecten (Camptonectes) curvatus, *F. Frech.* Zeitschr. d. deutsch. geol. Gesellsch., vol. xxxix, p. 155, pl. xix, fig. 18.

? 1889. — virgatus, *E. Holzapfel.* Die Mollusk. Aachen. Kreide (Palæontographica, vol. xxxv), p. 229, pl. xxvi, figs. 7—9.

? — (Camptonectes) virgatus, *O. Griepenkerl.* Die Verstein. der. Senon. von Königslutter (Palaeont. Abhandl., vol. iv), p. 46.

? curvatus, *A. Fritsch.* Stud. im Gebiete der böhm. Kreideformat. IV, Die Teplitz. Schicht., p. 85.

1892. PECTEN VIRGATUS, *F. Vogel.* Verhandl. nat. Vereins d. preussisch. Rheinl., vol. xlix, p. 55.

? 1893. — cf. CURVATUS, *R. Michael.* Zeitschr. d. deutsch. geol. Gesellsch., vol. xlv, p. 236.

? — — CURVATUS, *A. Fritsch.* Stud. im Gebiete der böhm. Kreideformat.: V, Priesen. Schicht., p. 100.

? 1895. — (CAMPTONECTES) VIRGATUS, *F. Vogel.* Holländisch. Kreide, p. 23.

? 1897. — CURVATUS, *A. Fritsch.* Stud. im Gebiete der böhm. Kreideformat.: VI, Die Chlomek. Schicht., p. 68.

? — — VIRGATUS, *A. Rutot.* Bull. Soc. Belge Géol., etc., vol. x, p. 30.

? — — — *R. Leonhard.* Die Kreideformat. in Oberschles. (Palæontographica, vol. xliv), p. 26.

? 1900. — — *C. Gagel and F. Kaunhowen.* Jahrb. d. k. preussisch. geol. Landesanst. u. Bergakad. für 1899, p. 231.

Non 1827. — ARCUATUS, *S. Nilsson.* Petrif. Suecana, p. 22, pl. ix, fig. 4.

— — — VIRGATUS, *Nilsson.* Ibid., p. 22, pl. ix, fig. 15.

— 1837. — — *W. Hisinger.* Lethæa Suecica, p. 52, pl. xvii, fig. 3.

— — — ARCUATUS, *Hisinger.* Ibid., p. 52, pl. xvii, fig. 2.

? — 1846. — VIRGATUS, *E. Forbes.* Trans. Geol. Soc., vol. vii, p. 154, pl. xv, fig. 22.

? — 1852. — — *F. Römer.* Die Kreidebild. von Texas, p. 66, pl. viii, fig. 5.

— 1866. — — *K. A. Zittel.* Die Biv. der Gosaugeb. II (Denkschr. d. k. Akad. Wissensch. Math.-nat. Cl. Wien, vol. xxv, pt. 2), p. 109 (33 of reprint), pl. xvii, fig. 8.

? — 1871. — (CAMPTONECTES) CURVATUS, *F. Stoliczka.* Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 433, pl. xxxi, figs. 15, 16; pl. xli, figs. 4—6.

? — 1884. CAMPTONECTES CURVATUS, *J. F. Whiteaves.* Mesozoic Fossils, vol. i, pt. 3 (Geol. and N. H. Survey, Canada), p. 242, pl. xxxii, fig. 4.

— 1897. PECTEN VIRGATUS, *A. Hennig.* Revis. Lamellibr. i Nilsson's 'Petrif. Suec.' (Kon. Fysiogr. Sällsk. Lund. Handl., N. F., vol. viii), p. 41, pl. ii, figs. 28, 33; pl. iii, figs. 32, 33.

Remarks.—This species closely resembles *P. striato-punctatus*, Römer, but generally possesses fewer ribs, and is, on the average, of smaller size. I have seen only two English specimens. One is a right valve from Great Haldon, 10 mm. in length and 11 mm. in height, with well-marked radial ribs on the ears crossed by much smaller concentric ribs. Another example, from the Chloritic Marl of Eastbourne, is 9 mm. in length and also in height. Without more English specimens, and without the opportunity of comparing them with collections of the foreign forms described as *P. virgatus*, etc., it is useless to attempt to discuss the relation of this to other Upper Cretaceous species.

Distribution.—Upper Greensand of Great Haldon. Chloritic Marl of Eastbourne.

PECTEN (CAMPTONECTES) DUBRISIENSIS, sp. nov. Plate XXIX, figs. 8 *a—c*.

Description.—Shell ovate, height a little greater than length, almost equilateral, margins evenly rounded. Umbones pointed. Apical angle about 117°. Ears rather large, unequal.

Right valve flattened, nearly smooth, with a few radial ribs near the antero-dorsal border, and occasional fine curving radial ornamentation like that on the left valve. Antero-dorsal margin slightly concave. Anterior ear long, with a deep byssal sinus, very sinuous growth-lines, and well-marked growth-ridges. Posterior ear triangular, with radial ribs and grooves.

Left valve moderately convex—the convexity greatest in the dorsal third, the ventral portions more compressed. Greater part of the surface smooth or nearly smooth; a few faintly marked growth-lines. Ornamentation seen on the sides of the umbonal region, also at the ventral edge, and for a short distance on the inner margin of some of the growth-lines; it consists of faintly marked outwardly curving ribs, separated by very narrow grooves, which are somewhat irregular and (in well-preserved specimens) punctate. Anterior ear large, not sharply separated from the rest of the valve, ornamented by a continuation of the radial ribs and grooves of the umbo, some of which cut the dorsal margin obliquely; the ribs are crossed by faint growth-ridges. Posterior ear smaller with similar ornamentation.

Measurements :

	(1)	(2)	(3)	(4)
Length	58	58	42	32 mm.
Height	63	59·5	46	35 ,,

(1) Totternhoe Stone, Cherry Hinton.
(2) Chalk Marl, Burham.
(3) Totternhoe Stone, Burwell.
(4) *H. subglobosus* zone, Hitchin.

Affinities.—The ornamentation is much less developed than in *P. striato-punctatus;* the shell is also larger, with a wider apical angle, less elevated ears, and with the left anterior ear indistinctly limited.

Remarks.—This is a comparatively rare form, which appears to be confined to the Chalk Marl and the zone of *H. subglobosus*.

Type.—Chalk Marl of Dover, British Museum, No. 38243.

Distribution.—Chalk Marl of Dover and Blue Bell Hill, Burham. Totternhoe

Stone of Cherry Hinton and Burwell. Zone of *H. subglobosus* of Hitchin. Lower Chalk of West Row near Mildenhall, and Stoke Ferry.

PECTEN (CAMPTONECTES ?) GAULTINUS, sp. nov. Plate XXX, figs. 1 *a*, *b*, 2.

Description.—Shell small, oval, a little higher than long, convexity small; somewhat inequilateral, the antero-dorsal border slightly concave and longer than the postero-dorsal, which is slightly convex. Ears very unequal. Apical angle from 95° to 100°.

Right valve flattened, nearly smooth, with faintly marked, nearly straight radial ribs near the anterior and posterior borders, separated by narrow punctate grooves; ribs and grooves absent or indistinct on the middle of the valve, except near the umbo. Anterior ear long, with a deep sinus, and three or four radial ribs crossed by growth-ridges. Posterior ear small, with its outer angle obtuse.

Left valve rather more convex, with similar ornamentation.

Measurements:

	(1)	(2)	(3)	(4)
Length .	22 .	15 .	14 .	17 mm.
Height .	19 .	17 .	16 .	19 ,,

(1—3) Gault, Black Ven.
(4) Gault, Folkestone.

Remarks.—This species differs from the typical *Camptonectes* in having the punctate grooves nearly straight instead of curving outwardly.

Types.—In the Woodwardian Museum, Cambridge.

Distribution.—Gault of Folkestone and Black Ven.

Sub-genus—CHLAMYS, *J. F. Bolten*, 1798.

('Museum Boltenianum,' p. 165.)

PECTEN (CHLAMYS) FISSICOSTA, *Etheridge*, 1881. Plate XXX, figs. 3, 4, 5 *a*, *b*, 6 *a*—*c*, 7, 8.

1881. PECTEN FISSICOSTA, *R. Etheridge*. In W. H. Penning and A. J. Jukes-Browne, Geol. of Cambridge (Mem. Geol. Survey), p. 141, pl. ii, fig. 1; pl. iii, fig. 1.

Description.—Shell ovate, slightly inequilateral; height greater than length, the difference increasing with age, usually in the proportion of 9 : 7 or 9 : 8, but in small specimens of 5 : 4·5. Valves compressed, the right flatter than the left; antero- and postero-dorsal margins nearly straight, the remainder regularly rounded and with corrugated edges. Apical angle about 90°, but larger (sometimes 100°) in small specimens. Ears unequal.

Right valve ornamented with strong, rounded, radial ribs, usually from sixteen to eighteen in number, but sometimes fewer or more (twelve to twenty-three). The ribs are separated by rather deep, rounded furrows, which are rather narrower than the ribs. At a distance from the margin of the valve, which varies in different specimens, some of the ribs are usually divided by a narrow groove, sometimes median, sometimes on one side; towards the umbo this groove becomes relatively more important, and divides the main rib into two equal and narrow ribs; and at the same time another similar rib may appear in the main furrow, giving the appearance of numerous slender ribs. All these ribs seem to die out before reaching the umbo, where the shell (to a length of about 5 mm.) is apparently smooth.[1] At distant intervals well-marked growth-ridges are seen, and also (in some cases) very fine concentric lines. The surface of both ribs and furrows (but especially the latter) is covered by close-set radial striæ, which at the middle of the valve are parallel with the main ribs, but, in passing to the anterior and posterior margins, become more and more oblique to the main ribs, and also more irregular and less continuous. Anterior ear large, produced, with a deep byssal sinus; surface with sinuous growth-lines (some strong), and two or three faintly marked radial ribs at the middle of the ear near its apex. Posterior ear smaller, not produced, triangular, with from seven to nine faintly marked radial ribs and growth-lines (two or three being strong); on the ventral part of the ear the fine striæ of the rest of the shell are continued, and cut the ribs obliquely.

Left valve with ribs similar to those of the right, but rather narrower, and separated by broader furrows. The ribs are sometimes divided by a small groove, which may reach the margin of the valve. In the main furrows there is frequently a small radial rib, which often ends at varying distances from the margin, but sometimes is continued, becoming stronger. Close-set radial striæ, like those on the right valve, occur on both ribs and grooves. Fine concentric ribs occur in places, especially on the earlier parts of the valve, and also, at intervals, strong growth-ridges. Ears triangular; the anterior larger, and with radial ribs and growth-lines; the posterior nearly smooth and with faint ribs.

[1] This may, however, be due to imperfect preservation.

Measurements :

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Length	45	40	36	36	35	27	26 mm.
Height	52	47	44·5	44	42	31	29 ,,

(1) Totternhoe Stone, Cherry Hinton.
(2—7) ,, ,, Burwell.

Affinities.—*P. fissicosta* is readily distinguished from the other species with strong ribs by its numerous radial striæ and by the fission of some of the main ribs. *P. landeronensis*, De Loriol,[1] resembles this species in form, but possesses a strongly marked concentric ornamentation. The radial striæ of *P. fissicosta* resemble those of *Camptonectes* as well as those seen in *P. Robinaldinus*, etc. The varieties, with few and undivided ribs (Pl. XXX, fig. 7), approach *P. decemcostatus*, Goldfuss (references on p. 167), but the valves are higher.

Types.—From the Totternhoe Stone, Burwell; in the Woodwardian Museum.

Distribution.—Chloritic Marl of Ventnor. Chalk Marl of Eggardon Hill (Dorset), Folkestone, and Blue Bell Hill, Burham. Totternhoe Stone of Arlesey, Cherry Hinton, Burwell, Orwell, and Stoke Ferry. Zone of *H. subglobosus* of Cherry Hinton.

Pecten (Chlamys) Puzosianus, *Matheron*, 1842. Plate XXX, figs. 9 *a*, *b*, 10 *a*, *b*, 11, 12.

1842. Pecten Puzosianus, *P. Matheron.* Catal. Foss. des Bouches-du-Rhône, p. 185, pl. xxx, figs. 1—3.
1847. — — *A. d'Orbigny.* Pal. Franç. Terr. Crét., vol. iii, p. 610, pl. ccccxxxvii, figs. 1—4.
1850. — — — Prodr. de Pal., vol. ii, p. 197.
1870. — — *F. J. Pictet and G. Campiche.* Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 5), p. 215.
1896. — cf. Puzosianus, *A. J. Jukes-Browne and W. Hill.* Quart. Journ. Geol. Soc., vol. lii, p. 151.

Description.—Shell ovate, higher than long, nearly equilateral and equivalve, dorsal portion pointed; antero- and postero-dorsal margins long. Convexity small, valves bent near the antero- and postero-dorsal margins. Apical angle about 90°. Ears large, unequal.

Right valve slightly convex, with numerous narrow ribs, which on the mid-dorsal parts of the valve are alternately large and small, but elsewhere become

[1] De Loriol and Gilliéron, 'Urgon. Infér. de Landeron' (1869), p. 22, pl. i, fig. 19; Pictet and Campiche, "Terr. Crét. de Ste. Croix" ('Matér. Pal. Suisse,' ser. 5, 1870), p. 187, pl. clxix, figs. 6, 7.

more nearly equal in size. Surface with concentric ridges or growth-lines, which sometimes develop into small spiny projections where they cross the ribs. Anterior ear large, rising dorsally, with a deep byssal sinus.

Left valve rather more convex, with usually from thirty-eight to forty-four ribs at the margin, where they are separated by very narrow grooves. Most of the ribs are of nearly equal size, but occasionally smaller ones occur; they are rounded on the early parts of the valve, but become flattened and broader ventrally, and also anteriorly and posteriorly. Secondary ribs are introduced at a short distance from the umbo. The grooves become narrow ventrally. Surface of ribs and grooves with close-set, concentric, linear ribs, which are better marked near the umbo than elsewhere. The bent antero- and postero-dorsal margins are without ribs, but have numerous radial striæ; these striæ appear on some of the ribs also. Anterior ear more elevated and larger than the posterior; both with a few broad radial ribs.

Measurements :

	(1)	(2)	(3)
Length .	42 .	39 .	35 mm.
Height .	50 .	49 .	42 ,,

(1) Cenomanian (Bed 11), Dunscombe.
(2) Cenomanian, Wilmington.
(3) Cenomanian (*A. Mantelli* zone), Beer Head.

Affinities.—The ribs in this species are more numerous as a rule, and the concentric ornamentation much less well-developed than in *P. Espaillaci*, d'Orbigny. The ribs are much more numerous than in *P. fissicosta*, Etheridge, and the radiating striæ much less developed, being apparently confined to the anterior and posterior part of the valves.

Remarks.—The English specimens are smaller than those figured by Matheron and d'Orbigny, and, as pointed out by Jukes-Browne, agree better with the figures than with the descriptions given by those authors, but specimens obtained from France leave no doubt as to the identity of the English form with Matheron's species. I have not seen the arrangement of the ribs shown in Matheron's section (fig. 3), but there is sometimes an alternation of large and small ribs.

Types.—Cenomanian (Chert Beds) of Les Martigues, Uchaux, and Mornas Sault.

Distribution.—Cenomanian of Wilmington. Cenomanian (Beds 10, 11) of Beer Head, and (Bed 11) of Dunscombe. Chloritic Marl of Melbury (Dorset) and Maiden Bradley.

PECTEN (CHLAMYS) BRITANNICUS, sp. nov. Plate XXXI, figs. 1 *a*, *b*, 2 *a*, *b*.

Description.—Shell thick, ovate, flattened, with even margins, slightly inequilateral, antero-dorsal margin a little longer than the postero-dorsal, apical angle about 90°.

Left valve with sixteen or more (sometimes probably thirty) strong, rounded, radial ribs, separated by deep grooves, which are frequently as broad as or broader than the ribs. The ribs merge into the smooth margin of the shell; they do not bifurcate, and only rarely is a new rib introduced between two others. Both ribs and grooves are marked by concentric, linear ridges, which are more distinct in the grooves than on the ribs, and are placed close together at regular intervals; the ridges imbricate upwards. Anterior ear moderately large, with the outer angle nearly rectangular, and one or two radial ribs. Posterior ear not seen.

Right valve not seen.

Measurements:

Length	26·0 mm.
Height	28·5 „

From *M. cor-anguinum* zone, South Croydon.

Affinities.—This species resembles *P. Espaillaci*, d'Orbigny,[1] from the Senonian of Dordogne and Charente-Inférieure, but it differs from the French form in possessing fewer ribs, with a stouter shell and thick margin (instead of a sharp and corrugated edge); also in the concentric ridges imbricating upwards, instead of downwards. A specimen of *P. Espaillaci* from the Dordonian has been sent me by M. A. de Grossouvre, and its concentric ridges are much better developed on the ribs, and in places are more scale-like, than in our species.

P. decemcostatus, Goldfuss,[2] possesses fewer ribs and is apparently without the fine concentric ridges.

P. fissicosta, Etheridge (p. 163), presents some resemblance to this species, but is easily separated by the divided and usually fewer ribs; also by the corrugated margin and the much less distinct concentric ridges, and by the occurrence of fine radial striæ.

[1] 'Pal. Franç. Terr. Crét.,' vol. iii (1847), p. 614, pl. ccccxxxix, figs. 1—4; d'Orbigny, 'Prodr. de Pal.,' vol. ii (1850), p. 251; F. J. Pictet and G. Campiche, "Foss. Terr. Crét. Ste. Croix" ('Matér Pal. Suisse," ser. 5, 1870), p. 215.

[2] 'Petref. Germ.,' vol. ii (1833), p. 53, pl. xcii, fig. 2; Geinitz, 'Das Elbthalgeb. Sachsen,' pt. ii (1872), p. 35, pl. x, figs. 8, 9.

A specimen from Lewes, figured by Mantell,[1] may perhaps be an example of this species.

Remarks.—Only three specimens have been seen, all coming from nearly the same horizon. The number of ribs on those from Haling and Gravesend is fewer than on the specimen from Stratford, but in other characters they agree.

Types.—In Dr. Blackmore's collection, and in Mr. G. E. Dibley's collection.

Distribution.—*M. cor-anguinum* zone of Haling pit, South Croydon, of Gravesend, and of Stratford, near Salisbury.

PECTEN (CHLAMYS) MILLERI, *Sowerby*, 1836. Plate XXXI, figs. 3 *a*, *b*, 4, 5, 6 *a*, *b*.

1836. PECTEN MILLERII, *J. de C. Sowerby.* Trans. Geol. Soc., ser. 2, vol. iv, pp. 241, 342, pl. xvii, fig. 19.
1850. — — *A. d'Orbigny.* Prodr. de Pal., vol. ii, p. 169.
1854. — MILLERI, *J. Morris.* Cat. Brit. Foss., ed. 2, p. 176.
1870. — — *F. J. Pictet and G. Campiche.* Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 5), p. 214.

Description.—Shell rather small, ovate, nearly equilateral, the dorsal third narrowing rapidly; height greater than length. Margins well rounded, but the antero-dorsal and postero-dorsal more or less concave, and the former longer than the latter; inequivalve. Apical angle about 99°. Ears very unequal.

Right valve slightly convex, flattened, with numerous slightly elevated, rounded radial ribs, which are smooth or slightly scaly, and separated by broader, shallow grooves. Anterior ear long, with a well-marked sinus; posterior ear much smaller, triangular, with outer angle obtuse.

Left valve much more convex than the right, especially in the median line towards the umbo; ornamented with numerous (usually 45 to 54) radial ribs, which are slightly elevated, flattened or rounded, and smooth (except a few of the posterior ribs); on the dorsal part the furrows are narrower than the ribs, and pitted, but ventrally they may be broader, and are always shallow. A secondary rib may appear in the furrows towards the ventral border. Anterior ear considerably larger than the posterior, with seven or eight radial ribs and a few growth-lines; its outer angle almost rectangular. Posterior ear smaller, with obtuse outer angle.

Measurements:

	(1)	(2)	(3)	(4)	(5)	(6)	
Length	28	26	21	20	13	12	mm.
Height	32	29·5	24	23	15	14·5	,,

(1—6) All from Blackdown.

[1] 'Foss. S. Downs' (1822), p. 203, pl. xxv, fig. 6.

Remarks.—The right valve is less common than the left. The state of preservation of the shell, and consequently the appearance of the ornamentation, varies a good deal.

Type.—From Blackdown; in the Bristol Museum.

Distribution.—Blackdown Greensand (Bed 10). Recorded by Downes (1882) from Haldon, and by Jukes-Browne (1900) from the Upper Greensand of Lulworth and Warminster.

PECTEN (CHLAMYS) SUBACUTUS, *Lamarck*, 1819. Plate XXXI, figs. 7 *a*, *b*, 8 *a*—*c*, 9.

1819.	PECTEN SUBACUTUS, *Lamarck.*	Anim. sans Vert., vol. vi, p. 181.
1836.	— — —	Ibid., ed. 2 (by Deshayes and Milne-Edwards), vol. vii, p. 158.
1847.	— — *A. d'Orbigny.*	Pal. Franç. Terr. Crét., vol. iii, p. 605, pl. ccccxxxv, figs. 5—10.
? —	— BRONGNIARTI, *A. d'Archiac.*	Mém. Soc. géol. de France, ser. 2, vol. ii, p. 310, pl. xvi, fig. 4.
1850.	— — *H. B. Geinitz.*	Das Quadersandst. oder Kreidegeb. in Deutschland, p. 183.
1870.	— SUBACUTUS, *F. J. Pictet and G. Campiche.*	Foss. Terr. Crét. Ste Croix (Matér. Pal. Suisse, ser. 5), pp. 214, 218.
1872.	— — *H. B. Geinitz.*	Das Elbthalgeb. in Sachsen (Palæontographica, vol. xx, pt. 1), p. 195, pl. xliv, fig. 5.
1877.	— — *A. J. Jukes-Browne.*	Quart. Journ. Geol. Soc., vol. xxxiii, p. 501.
1896.	— — — *and W. Hill.*	Ibid, vol. lii, p. 151.

Description.—Shell ovate, pointed dorsally, much higher than long, nearly equilateral, convexity small. Apical angle about 80°.

Right valve with about twenty-three strong ribs, which are straight or slightly curved, and have usually sharp summits, but are sometimes rounded; the grooves separating the ribs are broad, with rounded or angular bases. Near the anterior and posterior margins the ribs are rather smaller; near the umbo they are often more rounded than elsewhere. Both ribs and grooves are crossed by numerous, fine, close-set, wavy, laminar ridges, which are more regular and distinct near the umbo than ventrally. The ribs usually bear along their summits many scaly knobs or short spines, which are often distributed at fairly regular intervals; sometimes these scaly spines are absent over part or almost the entire shell. Anterior ear large, with a deep sinus; growth-ridges well-marked, radial ribs indistinct. Posterior ear much smaller, triangular, with radial ribs.

Left valve a little more convex, with similar ornamentation; ears slightly unequal.

Measurements:

	(1)	(2)	(3)
Length	37	34	24 mm.
Height	49	43	31 ,,

(1) Greensand, Haldon.
(2, 3) Chalk Marl (Bed 11), Dunscombe.

Affinities.—*P. acuminatus*, Geinitz,[1] resembles closely this species, but seems to differ from it in having few or no scaly spines on the ribs, and also in having the concentric ornament somewhat coarser; the ribs, as a rule, are also less sharp and somewhat less numerous. The state of preservation of the spines in *P. subacutus* varies a good deal in different specimens; in some cases (as in fig. 8) they are absent from the greater part of the surface. It seems probable, therefore, that the comparison of good series of specimens might show *P. acuminatus* and *P. subacutus* to be identical.

The form from the Cambridge Greensand, referred to this species by Jukes-Browne, possesses the characteristic concentric ornamentation, but has rather more numerous ribs; only three specimens have been seen, and since they are rather imperfectly preserved, the determination of the species cannot be regarded as quite certain.

Type.—From the Cenomanian of Le Mans.

Distribution.—Cenomanian:—Bed 10 of Hooken, Beds 11 and 12 of Dunscombe, Bed 12 of Branscombe. Greensand of Haldon. ? Cambridge Greensand.

Pecten (Chlamys) elongatus, *Lamarck*, 1819. Plate XXXI, figs. 10, 11 *a*, *b*, 12 *a*, *b*, 13; Plate XXXII, figs. 1 *a*, *b*, 2 *a*, *b*, 3 *a*, *b*.

1819. Pecten elongatus, *Lamarck*. Anim. sans Vert., vol. vi, p. 181.
1822. — obliquus, *J. de C. Sowerby*. Min. Conch., vol. iv, p. 95, pl. ccclxx, fig. 2.

[1] Geinitz, 'Char. d. Schicht. u. Petref. des sächs-böhm. Kreidegeb.,' pt. 3 (1842), p, 84, pl. xxi, fig. 6; Reuss, 'Die Verstein. der böhm. Kreideformat.,' pt. 2 (1846), p. 29, pl. xxxix, figs. 20, 21; d'Archiac, 'Mém. Soc. géol. de France,' ser. 2, vol. ii (1847), p. 309, pl. xvi, fig. 3; Kunth, 'Zeitschr. d. deutsch. geol. Gesellsch.,' vol. xv (1863), p. 725; Michael, ibid., vol. xlv (1895), p. 235; Römer, 'Geol. v. Oberschles.' (1870), p. 333, pl. xxvi, fig. 3; Geinitz, "Das Elbthalgeb. in Sachsen" ('Palæontographica,' vol. xx, pt. i, 1872), p. 194, pl. xliii, fig. 16; pl. xliv, fig. 1; Fritsch, 'Böhm. Kreideformat. III. Iserschicht.' (1883), p. 116, fig. 89; Nötling, "Die Fauna d. baltisch. Cenoman." ('Palaeont. Abhandl.,' vol. ii, 1885), p. 19, pl. iii, fig. 2; Leonhard, "Die Kreideformat. in Oberschles." ('Palæontographica,' vol. xliv, 1897), p. 26.

1825.	Pecten	elongatus, *Defrance.* Dict. Sci. nat., vol. xxxviii, p. 265.
1833.	—	cretosus, *A. Goldfuss* (non *Defrance*). Petref. Germ., vol. ii, p. 58, pl. xciv, fig. 2.
1836.	—	elongatus, *Lamarck.* Anim. sans Vert., ed. 2 (by G. D. Deshayes and H. M. Edwards), vol. vii, p. 158.
1839.	—	cretosus, *H. B. Geinitz.* Char. d. Schicht. u. Petref. des sächs. Kreidegeb., pt. 1, p. 22.
1841.	—	crispus, *F. A. Römer.* Die Verstein. d. nord-deutsch. Kreidegeb., p. 51.
—	—	comans, *Römer.* Ibid., p. 51, pl. viii, fig. 6.
1842.	—	Faujasi, *H. B. Geinitz.* Char. d. Schicht. u. Petref. des sächs.-böhm. Kreidegeb., pt. 3, p. 83.
—	—	comans, *Geinitz.* Ibid., p. 83.
1846.	—	faujasi, *H. B. Geinitz.* Grundriss der Verstein., p. 468.
—	—	crispus, *A. E. Reuss.* Die Verstein. der böhm. Kreideformat., pt. 2, p. 30.
? 1847.	—	elongatus, *A. d'Orbigny.* Pal. Franç. Terr. Crét., vol. iii, p. 607, pl. ccccxxxvi, figs. 1—4.
—	—	Raulinianus, *d'Orbigny.* Ibid., p. 595, pl. ccccxxxiii, figs. 6–9.
1850.	—	elongatus, *d'Orbigny.* Prodr. de Pal., vol. ii, p. 169.
—	—	crispus, *d'Orbigny.* Ibid., p. 169.
—	—	Raulinianus, *d'Orbigny.* Ibid., p. 139.
—	—	elongatus, *H. B. Geinitz.* Das Quadersandst. oder Kreidegeb. in Deutschland, p. 182.
—	—	comans, *Geinitz.* Ibid., p. 180.
1853.	—	Raulinianus, *F. J. Pictet and W. Roux.* Moll. Foss. Grès verts de Genève, p. 510, pl. xlvi, fig. 2.
1854.	—	elongatus, *J. Morris.* Cat. Brit. Foss., ed. 2, p. 176.
—	—	Marrotianus, *Morris* (non *d'Orbigny*). Ibid., p. 176.
? —	—	Raulinianus, *Morris.* Ibid., p. 177.
1870.	—	obliquus, *F. J. Pictet and G. Campiche.* Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 5), p. 214.
—	—	elongatus, *Pictet and Campiche.* Ibid., pp. 214, 218.
—	—	Raulinianus, *Pictet and Campiche.* Ibid., pp. 202, 213, pl. clxxii, figs. 5—7.
1872.	—	elongatus, *H. B. Geinitz.* Das Elbthalgeb. in Sachsen (Palæontographica, vol. xx, pt. 1), p. 195, pl. xliv, figs. 2—4.
1876.	—	crispus, *H. Deicke.* Die Tourtia von Mülheim a. d. Ruhr, p. 26.
1877.	—	Raulinianus ?, *A. J. Jukes-Browne.* Quart. Journ. Geol. Soc., vol. xxxiii, p. 501.
1878.	—	elongatus, *C. Barrois.* Ann. Soc. géol. du Nord, vol. v, p. 318 (foot-note 4).
? 1881.	—	cf. elongatus, *J. Kiesow.* Schrift. der naturf. Gesellsch. in Danzig, vol. v, p. 415, fig. 11.
1883.	—	Raulinianus, *W. Keeping.* Foss., etc., Neoc. Upware and Brickhill, p. 104.

? 1885. PECTEN ELONGATUS, *F. Nötling*. Die Fauna d. baltisch. Cenoman. (Palaeont. Abhandl., vol. ii), p. 20, pl. iii, fig. 6.
1887. — — *A. Peron*. Hist. du Terr. de Craie (Bull. Soc. Sci. hist. et nat. de l'Yonne, ser. 3, vol. xii), p. 163.
1893. — — *R. Michael*. Zeitschr. d. deutsch. geol. Gesellsch, vol. xlv, p. 235.
1895. — (CHLAMYS) ELONGATUS, *E. Tiessen*. Ibid., vol. xlvii, p. 468.
1896. — ELONGATUS, *A. J. Jukes-Browne and W. Hill*. Quart. Journ. Geol. Soc., vol. lii, p. 151.
1900. — — *Jukes-Browne*. Cret. Rocks of Britain (Mem. Geol. Survey), vol. i, p. 451.

Non 1833. — — *A. Goldfuss*. Petref. Germ., vol. ii, p. 59, pl. xciv, fig. 7.
— 1844. — — *F. M'Coy*. Carb. Limest. Foss. Ireland, p. 92, pl. xvi, fig. 9.
— 1846. — COMANS, *A. E. Reuss*. Die Verstein. der böhm. Kreideformat., pt. 2, p. 29, pl. xxxix, fig. 13.
? — — — OBLIQUUS, *Reuss*. Ibid., p. 29, pl. xxxix, fig. 18.
— 1871. — ELONGATUS, *J. Phillips*. Geol. Oxford, etc., p. 441, pl. xvii, fig. 19.

Description.—Shell ovate, pointed dorsally, higher than long, of little convexity, nearly equilateral. Ears rather large, very unequal. Apical angle from 78° to about 90°.

Right valve flattened or slightly convex, ornamented with numerous ribs, which are frequently grouped in triplets—a larger central rib with a smaller on each side—but sometimes occur in pairs or singly. The smaller ribs appear at varying distances from the umbo in different specimens. Each rib bears many lappet-like scaly projections placed transversely; these are sometimes close together and arranged very regularly, but may be more distant and somewhat irregular. In places fine growth-ridges are present. The grooves between the ribs are rather narrow and rounded. Narrow portions of the valves at the antero- and postero-dorsal margins are without ribs, but are covered by numerous fine grooves placed nearly perpendicularly to the plane of junction of the valves. Ears with radial ribs, which are often indistinct, and with well-marked growth-lines; on the posterior ear striæ (like those on the margin of the valve) are sometimes seen crossing the ribs; anterior ear large with a deep sinus, posterior ear smaller, triangular.

Left valve of moderate convexity with ornamentation similar to that of the right valve. Ears triangular, with many spiny ribs; the anterior larger than the posterior.

Measurements :

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	
Length .	43	41	37	33	20	35	56	60	56	40	38	28·5	13	36	50	60	35	55	mm.
Height .	53	51	47	41·5	25	44	65	73	66	50	49	34	17	47	58	74	45	65	,,

(1—5) Gault, Folkestone.
(6) Upper Greensand, Warminster.
(7) ,, ,, Ventnor.
(8) Malmstone, Wilton.
(9—13) Grey Chalk, Dover.
(14) Chalk Marl, Ventnor.
(15—17) Lower Chalk, Burwell.
(18) Totternhoe Stone, Arlesey.

Affinities.—The examples from the Gault (usually named *P. Raulinianus*) have been regarded as distinct from those found in the Upper Greensand and Chalk (*P. elongatus*); in the former the ribs usually appear to be more prominent owing to the longer and more pointed scales, and generally the triple arrangement of the ribs is not so well-marked as in the latter. The first difference is, I think, readily explained by the less perfect preservation of the spiny scales in specimens from the pervious beds of the Upper Greensand and Chalk; the triple arrangement of the ribs varies considerably in different specimens of *P. elongatus* from the Chalk and Greensand, and some forms with less regular triplets seem to be quite inseparable from the examples found in the Gault; on the other hand, a few Gault specimens have the triplets well and regularly developed. Mr. Jukes-Browne and Dr. F. L. Kitchin have examined carefully a number of specimens, and agree with me in considering that the differences between *P. elongatus* and *P. Raulinianus* are not of specific value.

P. Marrotianus, d'Orbigny,[1] from the Upper Senonian of Dordogne, resembles *P. elongatus*, but is apparently distinguished by the ears being less unequal, and by the anterior left ear having fewer and more distinct ribs; also the scales on the ribs of the valve are closer together and more numerous, and in the grooves between the triplets of ribs there are, in the adult, two small ribs.

P. Faujasi, Defrance,[2] from the *B. mucronata* Chalk of Maestricht, approaches very closely those forms of *P. elongatus* which have the triple arrangement of the ribs well developed, but appears to differ in having fewer ribs.

Remarks.—The specimens figured as *P. Raulinianus* by Pictet and Roux, and by Pictet and Campiche, seem to differ from the English forms in having fewer ribs; in this respect, however, the figures of those writers do not agree with their descriptions. But since Pictet and Campiche obtained specimens from Folkestone for comparison it is probable that their determination is correct. The example

[1] 'Pal. Franç. Terr. Crét.,' vol. iii (1847), p. 612, pl. ccccxxxviii, figs. 1—6.

[2] Faujas-St.-Fond, 'Hist. Nat de la Mont. de St. Pierre de Maestricht' (1799), p. 153, pl. xxiv, fig. 5; Defrance, 'Dict. Sci. nat.,' vol. xxxviii (1825), p. 265; Goldfuss, 'Petref. Germ.,' vol. ii (1833), p. 57, pl. xciii, fig 7; ? Reuss, 'Verstein. böhm. Kreideformat.,' pt 2 (1846), p. 30; Schröder, 'Zeitschr. d. deutsch. geol. Gesellsch.,' vol. xxxiv (1882), p. 265; Vogel, 'Verhandl. nat. Vereins d. preussisch. Rheinl.,' vol. xlix (1892), p. 59, and 'Hollandisch. Kreide' (1895), p. 24, pl. i, fig. 22.

figured as *P. elongatus* by d'Orbigny appears to belong to another species. *P. obliquus*, Sowerby, is probably identical with *P. elongatus;* the type, however, is missing, and the figures do not show the character of the ornamentation satisfactorily, but it is clear from the description that the ribs were in triplets and covered with numerous scales.

This is a moderately common species in the Upper Greensand and Lower Chalk. In a specimen from the Chalk Marl of Ventnor (Pl. XXXI, fig. 12) the shell is proportionately higher, and has a smaller apical angle than usual; it is near to the form figured by Geinitz (1872, pl. xliv, figs. 2, 3). Other specimens connect this high form with those of normal proportions. A few specimens from the Lower Greensand of Upware—now in the Woodwardian Museum, and in Mr. J. F. Walker's collection, were referred by W. Keeping to *P. Raulinianus;* their state of preservation is less satisfactory than that of Upper Cretaceous examples, but they approach closely some forms of *P. elongatus* from the Upper Greensand and Chalk, and are probably correctly referred to that species.

Types.—The type of *P. elongatus* came from the Cenomanian of Le Mans. The type of *P. obliquus* from the Upper Greensand (? Devizes) cannot be found in the Sowerby collection. The types of *P. Raulinianus* came from the Albian of Grand Pré and Machéroménil (Meuse).

Distribution.—Gault of Folkestone (zones viii and xi of Price). Cambridge Greensand. Upper Greensand of Ventnor. Malmstone of Alton. Chloritic Marl of Maiden Bradley. Rye Hill Sand of Warminster. Chalk Marl of Ventnor, Folkestone, and Burwell. Totternhoe Stone (*H. subglobosus* zone) of Arlesey and Burwell. Lower Greensand of Upware (see "Remarks" above).

PECTEN (CHLAMYS) CRETOSUS, *Defrance*, 1822. Plate XXXII, figs. 4 *a—d*, 5 *a*, *b*, 6 *a—c*; Plate XXXIII.

1822. PECTEN CRETOSUS, *Defrance*. *A. Brongniart*. Descript. géol. Envir. de Paris (in *Cuvier's* Ossem. foss., vol. ii), pp. 251, 598, pl. iii, fig. 7.
— — ARACHNOIDES, *Defrance*. *Brongniart*. Ibid., pp. 251, 599, pl. iii, fig. 8.
— — NITIDA, *G. Mantell*. Foss. S. Downs, p. 202, pl. xxvi, figs. 4, 9 (? fig. 1).
1823. — NITIDUS, *J. de C. Sowerby*. Min. Conch., vol. iv, p. 130, pl. cccxciv, fig. 1.
1825. — CRETOSUS, *Defrance*. Dict. Sci. nat., vol. xxxviii, p. 267.
— ARACHNOIDES, *Defrance*. Ibid., p. 266.

1841. PECTEN NITIDUS, *F. A. Römer.* Die Verstein. nord-deutsch. Kreidegeb., p. 52.

1845. — UNDULATUS, *A. d'Orbigny.* In Murchison, de Verneuil, and de Keyserling's Géol. Russ. d'Europe, vol. ii, p. 490, pl. xliii, figs. 8—10.

1846. — NITIDUS, *A. E. Reuss.* Die Verstein. der böhm. Kreideformat., pt. 2, p. 28.

1847. — CRETOSUS, *A. d'Orbigny.* Pal. Franç. Terr. Crét., vol. iii, p. 617, pl. cccexl, figs. 1—7.

1848. — NITIDUS, *H. G. Bronn.* Index Palæont., vol. i, p. 927.

1850. — CRETOSUS, *H. B. Geinitz.* Das Quadersandst. oder Kreidegeb. in Deutschland, p. 182.

— — *A. d'Orbigny.* Prodr. de Pal., vol. ii, p 251.

— — NITIDUS, *A. d'Orbigny.* Ibid., p. 252.

— — ZEISNERI, *A. Alth.* Geog.-pal. Beschreib. der nächst. Umgeb. von Lemberg (Haidinger's Naturwiss. Abhandl., vol. iii, pt. ii), p. 249, pl. xii, fig. 36.

? — — ARCUATUS, *Alth* (non *Sowerby*). Ibid., p. 245, pl. xii, fig. 29.

— — SUBINTERSTRIATUS, *F. Dixon* (non *d'Archiac*). Geol. Sussex, p. 356, pl. xxviii, fig. 19.

1854. — NITIDUS, *J. Morris.* Cat. Brit. Foss., ed. 2, p. 176.

— — CRETOSUS, *Morris.* Ibid., p. 176.

? 1866. — — *K. A. Zittel.* Die Biv. der Gosaugeb. (Denkschr. d. k. Akad. Wissensch. Math.-nat. Classe, vol. xxv), p. 112 (36 of reprint), pl. xviii, fig. 2.

1869. — ZEISNERI, *E. Favre.* Moll. Foss. de Lemberg, p. 146, pl. xiii, fig. 2.

1870. — CRETOSUS, *F. Römer.* Geol. Oberschles., p. 316, pl. xxxvii, fig. 6.

— — — *F. J. Pictet and G. Campiche.* Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 5), pp. 215, 218.

1871. — — *F. Stoliczka.* Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 428.

— — NITIDUS, *Stoliczka.* Ibid., p. 428.

1872. — CRETOSUS, *H. B. Geinitz.* Das Elbthalgeb. in Sachsen (Palæontographica, vol. xx, pt. ii), p. 34, pl. x, figs. 5, 6.

1882. — — *H. Schröder.* Zeitschr. d. deutsch. geol. Gesellsch., vol. xxxiv, p. 265.

— — — var. NITIDA, *Schröder.* Ibid., p. 266.

1887. — — *A. Peron.* L'Hist. Terr. de Craie (Bull. Soc. Sci. hist. et nat. de l'Yonne, ser. 3, vol. xii), p. 164.

1889. — — *O. Griepenkerl.* Senon. von Königslutter (Palæont. Abhandl., vol. iv), p. 41 (not the synonymy).

— — — *A. Fritsch.* Stud. im Gebiete der böhm. Kreideformat.: IV, Die Teplitz. Schicht., p. 85.

1892. — (CHLAMYS) CRETOSUS, *E. Stolley.* Die Kreide Schleswig-Holsteins (Mitth. Min. Inst. Kiel, vol. i), p. 239.

1897. — CRETOSUS, *R. Leonhard.* Kreideformat. in Oberschles. (Palæontographica, vol. xliv), p. 45.

? 1897. PECTEN CRETOSUS, var. NITIDA, *A. Hennig.* Revis. af Lamell. i Nilsson's 'Petrif. Suecana' (Kon. Fysiogr. Sällsk. i Lund. Handl., N. F., vol. viii), p. 49.
1898. — — *G. Müller.* Mollusk. d. Untersenon v. Braunschweig, etc. (Abhand. d. k. preussisch. geol. Landesanst., N. F., Heft 25), p. 31, pl. v, fig. 1.
1900. — — var. ZEISNERI, *C. Gagel and F. Kaunhowen.* Jahrb. d. k. preussisch. geol. Landesanst. u. Bergak. für 1899, p. 229.
— — — *A. Wollemann.* Die Fauna Senons von Biewende (ibid., 1900), p. 16.
1902. — — *J. P. J. Ravn.* Mollusk. i Danmarks Kridtafl. I. Lamellibr. (K. Danske Vid. Skrift. 6 Raekke, nat. math. Afd., vol. xi), p. 88, pl. i, figs. 11, 18.
— — — var. NITIDA, *Ravn.* Ibid., p. 88, pl. i, figs. 12, 13, 21.

Non 1833. — — *A. Goldfuss.* Petref. Germ., vol. ii, p. 58, pl. xciv, fig. 2 (= *crispus*, Römer, and *elongatus*, Lamarck).

Description.—Shell thin, ovate, higher than long, slightly inequilateral, rounded ventrally, antero-dorsal margin slightly concave, postero-dorsal margin straight or slightly convex. Valves of slight convexity. Apical angle varying from 90° to 105°. Ears moderately large, unequal.

Right valve flattened or slightly convex, with numerous narrow ribs which may be very slender or moderately strong; the interspaces are sometimes broader than the ribs, but narrower when the ribs are more numerous. In the interspaces are numerous regularly placed, linear, concentric ridges, which may be confined to the neighbourhood of the umbo, or may cover a larger part, or even the entire surface of the valve; these ridges are usually closer together ventrally than near the umbo. At some distance from the umbo, in a few or in many of the interspaces, new ribs appear, and sometimes remain throughout smaller than the primary ribs, but in other cases rapidly become of the same size as the primaries. Near the antero- and postero-dorsal edges of the valve the radial ribs are absent, and numerous fine striæ are placed nearly perpendicular to the edge. The ribs bear numerous spiny processes, which are usually scale-like and placed transversely, but may be more pointed or rounded and nodular; these processes may occur over the entire surface or be confined to parts, and they vary in size on different specimens. Anterior ear long, with a deep sinus; dorsal portion smooth, but between that and the sinus are from three to five spiny ribs, which are usually rather indistinct. Posterior ear smaller, triangular, with the outer angle slightly obtuse; with seven or eight radial ribs bearing scaly or nodular processes, and sometimes crossed by concentric ridges.

Left valve rather more convex than the right, and with similar ornamentation, but the ribs usually rather stronger, and sometimes more numerous; the concentric ridges are often less distinct, except near the umbo; ventrally, they are often placed very close together. Anterior ear with the outer edge convex, and eight to eleven radial ribs which are slightly spiny; the dorsal margin without ribs. Posterior ear smaller, with the outer angle obtuse, and with eight or nine ribs which are slightly spiny.

Measurements:

	M. cor-anguinum zone.				*Marsupites* zone.		*A. quadratus* zone.											*B. mucronata* zone.							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
Length	31	32	34	28	27	36	24	27	27·5	32	33·5	35	38	41	42	43	49	23	24	25	25	28	36	37	41 mm.
Height	38	37	38	33	28·5	42	28	32	33	36	39	40	42	47	48	48	55	27	28	30	31	33	42	44	48 ,,

(1) *M. cor-anguinum* zone, Porton, Salisbury.
(2, 3) ,, ,, Gravesend.
(4) ,, ,, Northfleet.
(5, 6) *Marsupites* zone, Witherington, Salisbury.
(7—17) *A. quadratus* zone, East Harnham, Salisbury.
(18—25) *B. mucronata* zone, Norwich.

Remarks.—This species varies greatly in the details of its ornamentation, and to some extent also in the proportions of height and length. The number, closeness, and strength of the ribs differ considerably; near the ventral margin of the valves they may be of equal size, or alternately large and small, owing to the later ribs still remaining smaller than the earlier ones. When the ribs are relatively few in number the flat interspaces are broader than the ribs, as in the form named *P. arachnoides*, Defrance; when the ribs are more numerous the interspaces are narrower than the ribs. For a short distance ventrally to a strong growth-line the ribs are sometimes deflected to one side. The narrow concentric ridges are usually distinct near the umbo, and may be absent or indistinct on the rest of the shell, or they may extend to varying distances from the umbo, and in some cases cover the entire shell. Usually the concentric ridges are well-spaced near the umbo, and become closer together ventrally, but sometimes they are equally distant all over the shell, or even become more widely separated ventrally. Spines are usually present near the umbo, and may be absent from all the rest of the shell, or may recur at the ventral border only; often they extend to about one-third of the distance from the umbo, or even cover the entire surface. In some cases alternating spiny and smooth concentric bands occur, the change taking place at well-marked growth-lines, *e. g.* spines near the umbo, in the middle of the valve and at the ventral border, separated by two smooth bands. In other cases the spines may be absent from the greater part of the valve. The "spines" vary in form, being usually scaly, but sometimes more pointed or nodular; in some cases they are

rather irregularly developed, but in others they are placed at very regular intervals, and are of very uniform size. The differences in the spines are in some cases connected with the state of preservation of the specimens. Nothing less than a large series of micro-photographs would illustrate adequately all the differences in the ornamentation of this species.

A few large specimens (length 67 mm., height 72 mm), from the *B. mucronata* zone of Norwich, appear at first sight to differ greatly from this species, on account of the greater part of the valves being nearly smooth, or marked with linear radial grooves separating flat interspaces; these forms agree perfectly in outline and in the form of the ears with some of the large examples of *P. cretosus*, and I believe they are only large and much-worn examples of that species, since the characteristic ornamentation sometimes occurs in the neighbourhood of the umbo for a distance of about 10 mm. (Norwich Museum, No. 2189), or, in other cases, just below well-marked growth-lines near the ventral border of the valve, where the shell has undergone less wearing (Norwich Museum, No. 2188).

In this variable species the extremes differ to such an extent in their ornamentation that, when considered separately, they appear as distinct species, but on examining a large series of specimens [1] a complete gradation is found to exist between the different forms, which we must therefore regard as merely modifications of one species.[2] The different forms, moreover, are not confined to one horizon or one locality, and it seems therefore hardly necessary to give them distinct names; but from the same zone and the same spot (*e. g.* East Harnham and Norwich) extreme forms and connecting links may sometimes be found. Moreover, in some cases two types of ornamentation appear on different parts of the same shell. The form with numerous strong ribs agrees with the type of *P. cretosus*, Defrance. *P. arachnoides*, of the same author, is the variety with relatively few and narrow ribs, with the spines poorly developed, and with regularly-placed concentric ridges. A variety with very slender and numerous ribs (found at Trimingham, etc.) agrees with the example figured as *P. undulatus* by Holzapfel. Another form with numerous well-developed, regularly placed, spiny scales on the fairly numerous radial ribs approaches *P. serratus*.

It is very difficult to decide which of the two names, *cretosus* or *nitidus*, has the priority, since the exact dates of publication of the works of Cuvier and Mantell cannot be determined at present. Mantell's preface is dated May 1st, 1822, and the work was received by the Geological Society before the end of June of that year. Mr. C. D. Sherborn informs me that the work of Cuvier was noticed as

[1] I have had the opportunity of studying over 200 examples.

[2] Dr. Blackmore, who has made a very large collection of *P. cretosus*, has independently come to the same conclusion—that all are forms of one species.

published in the 'Bibliographie de la France' for June 8th, 1822, and he is inclined to think that it appeared somewhat earlier than Mantell's book.

Affinities.—*P. undulatus*, Nilsson,[1] and *P. serratus*,[2] Nilsson, are very closely allied to *P. cretosus*, but the examination of a large series of specimens could alone enable us to determine their exact relationships.

Types.—The types of *P. nitidus* (from Lewes and Brighton) cannot be found, but the specimen from Gravesend figured by Sowerby is in the British Museum. The types of *P. cretosus* and *P. arachnoides* came from the Upper Senonian of Meudon. I have not seen the types, but specimens from the same locality are in the Wiltshire Collection, and another has been sent to me by M. A. de Grossouvre.

Distribution.—*R. Cuvieri* zone of Dover. *T. gracilis* zone of the Dorset coast and Dover. *H. planus* zone of the Sussex coast and Dover. *M. cor-testudinarium* zone of the Sussex coast, Dover, Purley, and Hitchin. *M. cor-anguinum* zone of the Dorset coast, Winchester, Porton (Salisbury), the Sussex coast, St. Margaret's, Thanet, Northfleet, Purley, Haling Pit (South Croydon), Bromley. *Marsupites* zone of the Dorset coast, Winchester, Witherington, the Sussex coast, and Thanet. *A. quadratus* zone of the Dorset coast, Winchester, East Harnham (Salisbury), and the Sussex coast. *B. mucronata* zone of the Dorset coast, Clarendon and Alderbury (Salisbury), and Norwich. Chalk of Trimingham.

PECTEN (CHLAMYS) MANTELLIANUS, *d'Orbigny*, 1847. Plate XXXIV, figs. 1 *a*, *b*, 2, 3 *a*—*c*, 4—6.

1833.	PECTEN CONCENTRICUS, *S. Woodward.*	Geol. Norfolk, p. 48, pl. v, figs. 27, 28.
1847.	— MANTELLIANUS, *A. d'Orbigny.*	Pal. Franç. Terr. Crét., vol. iii, p. 619, pl. ccccxl, figs. 8—11.
1850.	— — —	Prodr. de Pal., vol. ii, p. 251.
1854.	— CONCENTRICUS, *J. Morris.*	Cat. Brit. Foss., ed. 2, p. 176.
1870.	— MANTELLIANUS, *F. J. Pictet and G. Campiche.*	Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 5), p. 215.

[1] 'Petrif. Suecana' (1827), p. 21, pl. ix, fig. 10; Holzapfel, "Mollusk. Aachen. Kreide" ('Palæontographica,' vol. xxxv, 1889), p. 235, pl. xxvi, figs. 1, 2; Hennig, Revision af Lamell. i Nilsson's 'Petrif. Suecana' (1897), p. 48, pl. iii, figs. 9—11; Strombeck, 'Zeitschr. d. deutsch. geol. Gesellsch.,' vol. xv (1863), p. 154; Schröder, ibid., vol. xxxiv (1882), p. 266.

[2] Op. cit. (1827), p. 20, pl. ix, fig. 9; Holzapfel, op. cit. (1889), p. 236, pl. xxvi, fig. 16; Hennig, op. cit. (1897), p. 50, pl. iii, fig. 15; Stolley, 'Die Kreide Schleswig-Holsteins' (1892), p. 238; Ravn, 'Mollusk. i Danmarks Kridtafl.' (1902), p. 89.

1871. PECTEN MANTELLIANUS (= CONCENTRICUS), *F. Stoliczka.* Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 428.
1879. — cf. CONCENTRICUS, *C. Barrois.* Ann. Soc. géol. du Nord, vol. vi, p. 452, pl. xii, fig. 4.
1889. — MANTELLI, *E. Holzapfel.* Die Mollusk. Aachen. Kreide (Palæontographica, vol. xxxv), p. 235, pl. xxvi, fig. 6.
1892. — (CHLAMYS) MANTELLIANUS, *E. Stolley.* Die Kreide Schleswig-Holsteins (Mittheil. Min. Inst. Kiel, vol. i), p. 237.

Non 1822. — CONCENTRICUS, *T. Say.* Journ. Acad. Nat. Sci. Philadelphia, vol. ii, pt. 2, p. 259.
— 1825. — — *Defrance.* Dict. Sci. nat., vol. xxxviii, p. 253.
— 1837. — — *F. C. L. Koch and W. Dunker.* Beitr nord-deutsch. Oolithgeb., p. 43, pl. v, fig. 8.

Description.—Shell rather small, thin, ovate, dorsal third pointed; inequilateral, higher than long; postero-dorsal margin straight or slightly convex, and longer than the antero-dorsal, which is straight or slightly concave. Apical angle from 86° to 90°. Ears moderately large, rather high, unequal.

Right valve flat, with several (usually from three to five) strong growth-ridges separated by considerable intervals, and fine radial and concentric ornament, which is often indistinct or absent on the later parts of the valve. Radial ornament consists of about eleven very slightly elevated ridges or folds, which become indistinct ventrally; on the summits of the ridges there are usually two fine linear ribs, and others (two or three) of the same kind in the shallow furrows; near the anterior and posterior margins the radial ridges are replaced by ribs. Concentric ornament consists of fine, close-set, regular, linear ridges, which bear minute pointed granules where they cross the radial ribs. Anterior ear considerably larger than the posterior, and slightly produced dorsally, with a distinct, but not deep, sinus; surface with growth-lines, which become sinuous near the valve—above the sinuous part there are faintly marked radial ribs. Posterior ear with an outer angle of about 90°, and with well-marked growth-lines.

Left valve convex, with several strong growth-ridges at intervals. Ornamentation consists of seventeen or eighteen main ribs, which are narrow and but little raised; they are separated by broad, very shallow furrows. In the middle of each furrow is a similar but smaller rib, which, near the ventral border, sometimes becomes almost as large as the main rib. At some distance from the umbo other smaller linear ribs (two to five) are introduced. In some cases all the radial ribs become indistinct near the ventral border, where the shell is then smooth, except for concentric ornament. The concentric ornament consists of regularly-placed, fine, linear ribs, which are more widely spaced near the umbo than elsewhere, and form

a pointed granule where they cross the radial ribs; near the ventral border the ribs are often very closely placed. Ears triangular, with a few growth-lines; the anterior with granular ribs and nearly rectangular outer angle, the posterior smaller and with obtuse outer angle.

Measurements:

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	
Length	39	38	33	32	30	28	26	20	mm.
Height	45	44	37	35	35	31	31	23	,,

(1—8) *B. mucronata* zone, near Norwich.

Affinities.—In form, and in the possession of similar radial and concentric ornamentation, this species resembles some of the varieties of *P. cretosus*, but is easily distinguishable by the stronger radial ridges, etc.

Remarks.—The differences in the appearance of the ornamentation in this species seem to depend mainly on the state of preservation; in some cases the right valve is almost smooth. Frequently in the larger specimens the later part of the valve is almost without ornament. By far the larger number of specimens which I have seen were obtained from the neighbourhood of Norwich, where it is a characteristic fossil.

Type.—The type of *P. concentricus*, Woodward, came from the Chalk of Norwich, but cannot now be found. The types of *P. Mantellianus*, d'Orbigny, came from the Senonian of Chavot (Marne).

Distribution.—*M. cor-anguinum* zone of South Croydon (Haling Pit). *B. mucronata* zone of Clarendon (near Salisbury), of Hartford Bridge and various other localities near Norwich. Upper Chalk of Sussex.

PECTEN (CHLAMYS) ROBINALDINUS, *d'Orbigny*, 1847. Plate XXXIV, figs. 7 *a*, *b*, 8 *a*, *b*, 9 *a*, *b*, 10 *a*, *b*, 11, 12 *a*—*c*; Plate XXXV, figs. 1—10.

1842. PECTEN INTERSTRIATUS, *A. Leymerie.* Mém. Soc. géol. de France, vol. v, p. 10, pl. xiii, fig. 1 (non *interstriatus*, Münster).

1845. — OBLIQUUS, *E. Forbes.* Quart. Journ. Geol. Soc., vol. i, p. 249 (non *obliquus*, Sowerby).

1847. — ROBINALDINUS, *A. d'Orbigny.* Pal. Franç. Terr. Crét., vol. iii, p. 587, pl. ccccxxxi, figs. 1—4.

? — — INTERSTRIATUS, *d'Orbigny.* Ibid., p. 594, pl. ccccxxxiii, figs. 1—5.

1850. — APTIENSIS, *A. d'Orbigny.* Prodr. de Pal., vol. ii, p. 119.

1852. Pecten aptiensis, *F. J. Pictet and W. Roux.* Moll. Foss. Grès verts de Genève, p. 511, pl. xlvi, fig. 3.
1854. — interstriatus, *J. Morris.* Cat. Brit. Foss., ed. 2, p. 176.
? 1861. — Robinaldinus, *P. de Loriol.* Anim. Invert. Foss. Mt. Salève, p. 101, pl. xii, figs. 9, 10.
? — — Barretti, *H. G. Seeley.* Ann. Mag. Nat. Hist., ser. 3, vol. vii, p. 118, pl. vi, fig. 1.
? 1869. — Robinaldinus, *P. de Loriol and V. Gilliéron.* Urgon. Inf. de Landeron (Mém. Soc. helvét. Sci. nat., vol. xxiii), p. 22.
1870. — — *F. J. Pictet and G. Campiche.* Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 5), p. 188, pl. clxx, figs 1–5.
1877. — aptiensis, *A. J. Jukes-Browne.* Quart. Journ. Geol. Soc., vol. xxxiii, p. 500.
? — — Barretti, *Jukes-Browne.* Ibid., p. 500.
? 1883. — Dutemplei, *W. Keeping.* Foss., etc., Neoc. Upware and Brickhill, p. 105.
1884. — Robinaldinus, *O. Weerth.* Die Fauna des Neocom. im Teutoburg. Walde (Palaeont. Abhandl., vol. ii), p. 53.
1895. — — *G. Maas.* Zeitschr. d. deutsch. geol. Gesellsch., vol. xlvii, p. 269.
1896. — — *A. Wollemann.* Ibid., vol. xlviii, p. 840.
— — Galliennei, Passyi, et subinterstriatus, *A. J. Jukes-Browne and W. Hill.* Quart. Journ. Geol. Soc., vol. lii, p. 150.
1900. — Robinaldinus, *A. Wollemann.* Die Biv. u. Gastrop. d. deutsch. u. holländ. Neocoms (Abhandl. d. k. preussisch. geol. Land., N. F., pt. 31), p. 47.
? 1900. — cf. Robinaldinus, *G. Müller.* In W. Bornhardt, Zur Oberflachen u. Geol. Deutsch-Afrikas (Deutsch-Ost-Afrika, vol. vii), p. 551.

Description.—Shell ovoid, pointed dorsally, higher than long, slightly inequilateral, of moderate convexity. Apical angle from 80° to 85°. Ears rather large, unequal.

Right valve ornamented with numerous narrow, slightly raised ribs, which are sometimes wavy, and are separated by flattened spaces, often of greater width than the ribs. The ribs bear numerous small, scaly spines, which are placed transversely and are generally close together, but sometimes more widely and regularly separated. Spaces between the ribs covered by numerous striæ, which in the middle of the valve are more or less parallel with the ribs, but become more and more oblique in passing towards the anterior and posterior borders. Anterior ear large, with a large sinus, well-marked growth-lines, and faint radial ribs. Posterior ear

much smaller, triangular, outer angle obtuse, marked with radial striæ like those on the valve.

Left valve rather more convex, ornamented with similar but fewer ribs, bearing scaly spines which are often placed at fairly regular intervals. Interspaces with striæ as on the right valve. Ribs generally of nearly uniform size; but in some cases smaller ribs are intercalated at some distance from the umbo, so that alternating larger and smaller ribs are clearly seen. Narrow concentric ridges, placed at regular intervals, are sometimes present near the umbo. Anterior ear large, with a few radial ribs—usually near the valve only, leaving the upper part smooth; ribs crossed by oblique striæ. Posterior ear small, with outer angle obtuse, and marked with striæ.

Remarks.—This species varies greatly; the number of ribs on the left valve ranges from 35 to 57, and consequently the width of the interspaces also varies. Sometimes smaller ribs are intercalated between some of the others. The spines on the ribs may be close together and numerous, or fewer and more widely separated, and sometimes they have a fairly distinct concentric arrangement; in some cases the ribs on part of a valve, or on almost the entire surface, are without spines. Such smooth or nearly smooth forms occur in the Hythe Beds of Hythe, the Chloritic Marl of Maiden Bradley, the Rye Hill Sand of Warminster, the Cenomanian (Bed 12) of Beer Head, etc. The sharpness of the spines varies in different specimens, and is partly dependent on the nature of the enclosing rock. Some examples from Faringdon and also some from the Upper Greensand (Pl. XXXV, fig. 3) have ribs over the whole of the anterior left ear, and the ribs on the valve are numerous with the spines irregularly placed; I have not sufficient specimens to determine whether these are distinct from the other forms, or merely a variety. Some forms (Pl. XXXV, fig. 1) with few and strong ribs, and well-developed scales, also appear at first sight to be distinct, but it is difficult to draw a line between them and the normal form.[1] A much larger series of specimens is required to determine whether these forms are really distinct, or merely varieties.

Mr. Jukes-Browne now agrees with me in regarding the forms which he named

[1] A form similar to this, but having more numerous ribs and with the spines usually more pointed and erect, obtained from the Cenomanian Sandstone of Wilmington, etc. (Pl. XXXV, fig. 10) has been referred by Jukes-Browne to *P. hispidus*, Goldfuss. The state of preservation of the specimens is not sufficiently good to enable me to decide as to their affinities, but I am inclined to regard them as constituting only a variety of *P. Robinaldinus*. In some examples of the latter the spines are almost, if not quite, as large as in the former. They agree better with the figures of Geinitz than of Goldfuss, but the ribbing appears to vary considerably. Goldfuss, 'Petref. Germ.,' vol. ii (1833), p. 59, pl. xciv, fig. 4; Pictet and Campiche, 'Foss. Terr. Crét. Ste. Croix' (1870), p. 215; Geinitz, 'Das Elbthalgeb. in Sachsen' ('Palæontographica,' vol. xx, pt. 1, 1872), p. 197, pl. xliv, figs. 9, 10; Jukes-Browne, 'Cret. Rocks of Britain,' vol. i (1900), p. 452.

(in 1897, see synonymy) *Galliennei*, *Passyi*, and *subinterstriatus* as identical with *P. Robinaldinus.*

The larger number of the specimens seen were obtained from the *Perna*-bed of Atherfield, the Rye Hill Sand of Warminster, the Chloritic Marl of Maiden Bradley, and the Cenomanian of the Devon coast.

Affinities.—This species is closely related to (and probably identical with) several forms described by d'Orbigny, d'Archiac, etc.

Pecten Passyi, d'Archiac,[1] from the Tourtia (Cenomanian) of Tournay, varies considerably, but is perhaps distinguished from *P. Robinaldinus* by the smaller intercalated ribs being more numerous and more distinct; in some cases (as in the type specimen) spines are absent from most of the ribs, but in other examples from Tournay, which I have seen, they are as numerous as in most specimens of *P. Robinaldinus.*

P. subinterstriatus, d'Archiac,[2] from the same horizon, appears to differ only in having very numerous ribs.

P. Dutemplei, d'Orbigny,[3] from the Gault, seems to be indistinguishable from *P. Robinaldinus*, except perhaps (as suggested by Pictet and Campiche) by the occurrence in *P. Dutemplei* of about fifteen ribs distributed over the whole surface of the anterior left ear, whereas (according to the same writers) in *P. Robinaldinus* seven or eight ribs only occur, and are confined to the lower part of the ear. But it is doubtful whether these characters are constant: in Leymerie's figure the ribs seem to be distributed over the whole ear; while in d'Orbigny's figure of *P. Robinaldinus* the ribs, although only six in number, are also distributed over the entire ear.

P. Galliennei, d'Orbigny,[4] is probably only a variety with rather fewer ribs on the valve, and with four or five ribs distributed over the anterior left ear. It is recorded by Pictet and Campiche from the Upper Greensand of Ventnor.

P. rhotomagenis, d'Orbigny,[5] from the Cenomanian of Rouen, is another similar form with numerous ribs.

P. Oosteri, de Loriol,[6] is likewise closely related to *P. Robinaldinus.*

The form figured by d'Orbigny as *P. interstriatus*, Leymerie, is probably only a variety, but it possesses fewer ribs than any English form which I have seen. It approaches, however, some examples found in the Upper Greensand.

The name *aptiensis* was proposed by d'Orbigny (1850) for the *interstriatus* of

[1] 'Mém. Soc. géol. de France,' ser. 2, vol. ii (1847), p. 309, pl. xv, fig. 9.

[2] Ibid., p. 311, pl. xv, fig. 10.

[3] 'Pal. Franç. Terr. Crét.,' vol. iii (1847), p. 596, pl. ccccxxxiii, figs. 10—13.

[4] Ibid., p. 608, pl. ccccxxxvi, figs. 5—8.

[5] Ibid., p. 609, pl. ccccxxxvi, figs. 9—11.

[6] 'Anim. Invert. Foss. Mt. Salève' (1861), p. 102, pl. xiii, figs. 4—8; de Loriol and Gilliéron, 'Urgon. infér. de Landeron' (1869), p. 23, pl. i, fig. 18; F. J. Pictet and G. Campiche, 'Foss. Terr. Crét. Ste. Croix' ('Matér. Pal. Suisse,' ser. 5, 1870), p. 192, pl. clxx, fig. 6.

Leymerie (*non* Münster); but *Robinaldinus*, which is one of the forms of this species with fewer and coarser ribs, has the priority. *P. aptiensis* is placed by Pictet and Campiche as a synonym of both *P. Robinaldinus* and *P. Dutemplei.*

Morris regarded *P. Dutemplei* and *P. Galliennei* as synonyms of *interstriatus*, Leymerie, and included in it both Upper and Lower Greensand forms.

P. Barretti, Seeley, from the Cambridge Greensand, is founded on a worn specimen, but is probably identical with *P. Robinaldinus*, unless the numerous ribs on the anterior left ear be regarded as a distinguishing character.

Types.—The type of *P. interstriatus*, Leymerie, came from Les Croûtes, Aube. D'Orbigny's specimens of *P. Robinaldinus* were obtained from the Neocomian of St. Sauveur, etc.

Distribution.—*Perna*-bed of Atherfield and East Shalford. Atherfield Beds of Sevenoaks. Hythe Beds of Hythe and Lympne. Lower Greensand of Faringdon, and perhaps Upware. Ferruginous Sands of Shanklin.

Chloritic Marl of Maiden Bradley. Upper Greensand of Ventnor. Rye Hill Sand of Warminster. Chalk Marl, zone of *A. Mantelli* (Meÿer's Beds 11 and 12) of Dunscombe, and Bed 11 of Beer Head.

PECTEN (CHLAMYS) STUTCHBURIANUS, *Sowerby*, 1836. Plate XXXV, fig. 11.

1836. PECTEN STUTCHBURIENSIS, *J. de C. Sowerby.* Trans. Geol. Soc., ser. 2, vol. iv, p. 342, pl. xviii, fig. 1.
— — STUTCHBURIANUS, *Sowerby.* Ibid., p. 360.
1854. — — *J. Morris.* Cat. Brit. Foss., ed. 2, p. 177.

Description.—Shell large, ovate, higher than long, flattened, convexity small. Ornamented with numerous slightly-raised ribs, which on the greater part of the valve are alternately broad and very narrow, and are separated by narrow grooves; but towards the margin the alternation of ribs may be less distinctly marked, and the interspaces broader with indications of oblique striæ: the larger ribs have flattened or rounded summits, and are ornamented with transversely-placed scales. Umbones pointed; apical angle rather small (about 85°); ears high, not very distinctly separated from the rest of the valve.

Measurements (approximate):

	(1)	(2)	(3)	(4)	
Length	90	79	50	58	mm.
Height	112	90	67	68	,,

(1—3) Haldon, (4) Blackdown.

Affinities.—No definite opinion can be given as to the affinities of this form,

since only imperfectly preserved specimens have been seen. The oblique striæ, and the scales on the ribs, however, seem to connect it with *P. Robinaldinus*, but it appears to be distinguished by the regular alternation of large and small ribs, and by its greater size. *P. Stutchburianus* presents some resemblance to one of the specimens from the Tourtia figured by d'Archiac[1] as *P. acuminatus*, Geinitz, but differs in the ribs being closer together and alternating in size.

Remarks.—The examples from Haldon differ from the type in having the scales on the ribs indistinct, but this difference is probably due to imperfect preservation.

Type.—Blackdown Greensand; in the Bristol Museum.

Distribution.—Greensand of Haldon and Blackdown.

Section ÆQUIPECTEN, *P. Fischer*,[2] 1886.

('Manuel de Conch.,' p. 944.)

PECTEN (ÆQUIPECTEN) ASPER, *Lamarck*, 1819. Plate XXXV, fig. 12; Plate XXXVI, figs. 1 *a*,*b*, 2, 3, 4.

1770. *M. Lister.* Conch., pl. cccclxx, fig. 28.
1813. OSTREA MURICATA, *J. Townsend.* The Character of Moses established for Veracity as a Historian, vol. i, pl. i, fig. 2.
1819. PECTEN ASPER, *Lamarck.* Anim. sans Vert., vol. vi, p. 180.
1820. PECTINITES ASPER, *E. T. v. Schlotheim.* Die Petrefactenkunde, p. 226.
1822. PECTEN ASPER, *J. de C. Sowerby.* Min. Conch., vol. iv, p. 95, pl. ccclxx, fig. 1.
— — — *A. Brongniart.* Descr. géol. Envir. de Paris (in *Cuvier's* Oss. Foss., vol. ii), pp. 320, 603, pl. v, fig. 1.
1825. — — *Defrance.* Dict. Sciences nat., vol. xxxviii, p. 261.
1832. — — *G. P. Deshayes.* Encyc. Méth. Vers, vol. iii, p. 728.
1833. — — *A. Goldfuss.* Petref. Germ., vol. ii, p. 58, pl. xciv, fig. 1.
1836. — — *G. P. Deshayes and H. Milne Edwards.* Ed. 2 of Lamarck's Anim. sans Vert., vol. vii, p. 157.
1837. — — *F. Dujardin.* Mém. Soc. géol. de France, ser. 2, vol. ii, p. 228.
? — — — var. POLONICA, *G. G. Pusch.* Polens Palæont., p. 41, pl. v, fig. 7.
1839. — — *H. B. Geinitz.* Char. d. Schicht. u. Petref. des sächs. Kreidegeb., pt. 1, p. 23.

[1] 'Mém. Soc. géol. de France,' ser. 2, vol. ii (1847), pl. xvi, fig. 3 (on the left-hand side, not the other fig. 3).

[2] I follow Dall in regarding *Æquipecten* as only a section of *Chlamys*. See 'Trans. Wagner Free Instit. Science of Philadelphia,' vol. iii (1898), p. 695.

1841. PECTEN ASPER, *F. A. Römer.* Die Verstein. d. nord-deutsch. Kreidegeb., p. 53.
1846. — — *H. B. Geinitz.* Grundriss der Verstein., p. 469.
— — — *A. E. Reuss.* Die Verstein. der böhm. Kreideformat., pt. 2, p 30, pl. xl, fig. 1.
1847. — — *A. d'Orbigny.* Pal. Franç. Terr. Crét., vol. iii, p. 599, pl. ccccxxxiv, figs. 1—6.
1850. — — *H. B. Geinitz.* Das Quadersandst. oder Kreidegeb. in Deutschland, p. 184.
— — — *A. d'Orbigny.* Prodr. de Pal., vol. ii, p. 168.
1852. — — *R. Kner.* Denkschr. d. k. Akad. d. Wissensch., Math.-nat. Cl., vol. iii, p. 317, pl. xvii, fig. 6.
1854. — — *J. Morris.* Cat. Brit. Foss., ed. 2, p. 175.
1855. — — *G. Cotteau.* Moll. Foss. de l'Yonne, p. 116.
1863. — — *A. Kunth.* Zeitschr. d. deutsch. geol. Gesellsch., vol. xv, p. 724.
1870. — — *F. J. Pictet and G. Campiche.* Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 5), pp. 208, 213.
1871. — (CHLAMYS) ASPER, *F. Stoliczka.* Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 428.
1872. — ASPER, *H. B. Geinitz.* Das Elbthalgeb. in Sachsen (Palæontographica, vol. xx, pt. 1), p. 198.
1876. — — *H. Deicke.* Die Tourtia von Mülheim a. d. Ruhr, p. 26.
1878. CHLAMYS ASPER, *E. Bayle.* Explic. de la Carte géol. de France, vol. iv, pt. 1 (Atlas), pl. cxxii, fig. 1.
1893. PECTEN ASPER, *R. Michael.* Zeitschr. d. deutsch. geol. Gesellsch., vol. xlv, p. 234.

Non 1830. — — *Hart* (fide *d'Orbigny*).
— 1852. — — *L. Reeve.* Conch. Icon., vol. viii, pl. ii, fig. 10.

Description.—Shell usually rather large, nearly circular, equilateral, almost equivalve; antero- and postero-dorsal margins of equal length, straight or slightly concave. Valves moderately convex—right valve a little more convex than the left. Length equal to, or slightly greater than, height. Umbones sharp. Apical angle about 105°. Ears moderately large, unequal.

Surface of both valves ornamented with about seventeen main ribs, which are angular and elevated; near the anterior and posterior borders they are sometimes rather smaller than elsewhere; on the ribs are numerous sharp, hollow, ventrally directed spines. Near the umbo only these main ribs occur, but at a little distance from it another similar but smaller rib, with similar spines, is introduced on each side of the main rib; and later other ribs usually appear successively—often one or two, but sometimes three or more on each side of the main rib. These lateral ribs are not always of equal size, and not always placed at equal distances from one another. The antero- and postero-dorsal margins of the valves

are bent nearly perpendicularly to the plane between the valves, and this narrow, bent portion is ornamented with close-set grooves only, placed nearly perpendicularly to the line between the valves.

Ears ornamented with radial spiny ribs. Posterior ears triangular; anterior ears larger—the right with a well-marked sinus.

Measurements :

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	
Length . .	76	71	67	67	65	62	60	57	55	49	mm.
Height . .	74	71	66	65	66	60	60	56	55	47	,,

(1) From the Cenomanian of Wilmington.
(2—10) From Warminster.

Affinities.—See *P. pexatus* (p. 190).

Remarks.—The number of lateral ribs varies to some extent, and in a few cases only one is found on each side of the main ribs throughout their length.

This species is abundant in the Upper Greensand of the south of England, especially at Warminster. It occurs less commonly in the Chloritic Marl, but is abundant in the Cenomanian of Devon.[1]

Type.—From the Cenomanian of Ferté Bernard (Sarthe). The specimen figured by Sowerby, from the Upper Greensand of Horningham near Frome, is in the British Museum.

Distribution.—Higher part of the Upper Greensand of Melcombe Bingham, Ballard Down, Ventnor, Savernake, Maiden Bradley, and Warminster. Rye Hill Sand of Maiden Bradley, Rye Hill, and Warminster. Chloritic Marl of Maiden Bradley and the Isle of Wight. Cenomanian (Meÿer's Beds 11 and 12) of the Devon coast and of Wilmington.

PECTEN (ÆQUIPECTEN) BEAVERI, *Sowerby*, 1817. Plate XXXVIII.

1817.	PECTEN	BEAVERI, *J. Sowerby.*	Min. Conch., vol. ii, p. 131, pl. clviii.
1822.	—	— *G. Mantell.*	Foss. S. Downs, p. 127, pl. xxv, fig. 11.
1825.	—	— *Defrance.*	Dict. Sci. nat., vol. xxxviii, p. 264.
? 1833.	—	— *A. Goldfuss.*	Petref. Germ., vol. ii, p. 54, pl. xcii, fig. 5.
—	—	DEPRESSUS, *Goldfuss.*	Ibid., p. 53, pl. xcii, fig. 4.
1837.	—	BEAVERI, *H. G. Bronn.*	Lethæa Geog., p. 677, pl. xxx, fig. 19 (ed. 3, vol. ii, pt. 5, p. 273).

[1] *Pecten compositus*, Sowerby ('Trans. Geol. Soc.,' ser. 2, vol. iv, 1836, p. 342, pl. xvii, fig. 20), from Blackdown, is probably a *Lima* related to *L. cenomanensis*, d'Orbigny. The type is in the Bristol Museum.

1841.	PECTEN BEAVERI, *F. A. Römer.*	Die Verstein. d. nord-deutsch. Kreidegeb., p. 54.
1850.	— ? BEAVERI, *A. d'Orbigny.*	Prodr. de Pal., vol. ii, p. 169.
—	— JUGOSUS, *J. de C. Sowerby,* in *F. Dixon.*	Geol. Sussex, p. 347 (p. 382, ed. 2), pl. xxviii, fig. 26.
1854.	— BEAVERI, *J. Morris.*	Cat. Brit. Foss., ed. 2, p. 175.
1863.	— — *A. v. Strombeck.*	Zeitschr. d. deutsch. geol. Gesellsch., vol. xv, p. 108.
1870.	— — *F. J. Pictet and G. Campiche.*	Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 5), pp. 214, 218.
1871.	— — *F. Stoliczka.*	Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 428.

Description.—Shell large, thin, oval or nearly circular; height usually slightly greater than length; margins evenly rounded except at the junction with the ears. Valves compressed, nearly equal, slightly inequilateral. Apical angle large, from 118° to 125°. Ears long, low, a little unequal.

Right valve with broad radial ribs, which have sharp and sometimes slightly irregular summits and gently sloping sides; there are also similar smaller ribs, which do not reach the umbo. The ribs are smaller anteriorly and posteriorly. The surface of the valve is ornamented with fine, close-set, concentric, linear ridges, and sometimes with radial ridges. Anterior ear with a well-marked sinus, ornamented with scaly ribs except near its junction with the valve. Posterior ear smaller, outer angle nearly a right angle; surface with ribs, sometimes obscured by concentric lamellæ.

Left valve with about seventeen main ribs, which are narrow, elevated, and sharp, sometimes slightly serrate at the summits; separated by broad furrows. A smaller rib is often introduced in the middle of the furrow at a distance from the umbo, and on the sides of the ribs other still smaller ribs may occur. Anteriorly and posteriorly the main ribs become smaller. The ribs and furrows are crossed by many fine, close-set, regular, concentric ridges, which are seen most distinctly in the furrows. Anterior ear a little more elevated than the posterior; both with radial ribs and sharp outer angles.

Measurements:

	(1)	(2)	(3)	(4)	(5)	(6)	
Length	81	86	88	106	96	109	mm.
Height	80	88	101	106	98	109	,,

(1, 2) Chalk Marl, Folkestone.
(3) ,, ,, Meldreth.
(4, 5) Totternhoe Stone, Burwell.
(6) *H. subglobosus* zone, Cherry Hinton.

Affinities.—*P. depressus*, Goldfuss, seems to be scarcely distinguishable from *P. Beaveri.* The specimen figured by Goldfuss as *P. Beaveri* does not show the

small ribs on the sides of the main ribs, and may perhaps be distinct, but this can be determined only by an examination of specimens.

Types.—The type was obtained from Lower Chalk of Childrey, near Wantage, and is said to be in the Oxford Museum. The type of *P. jugosus* is missing, and the locality from which it was obtained is not given by Sowerby. Mantell's figured specimen, from the Chalk Marl of Hamsey, also appears to have been lost.

Distribution.—Upper Gault (zone x) of Folkestone. Red Limestone of Hunstanton (*fide* Survey Memoirs). Chloritic Marl of Blackgang and Niton. Chalk Marl of Ventnor, Folkestone, Meldreth, Hunstanton, Stoke Ferry, etc. Totternhoe Stone of Cherry Hinton, Burwell, Dersingham, and Hunstanton. *H. subglobosus* zone of Blue Bell Hill (Burham), Shelford, and Cherry Hinton.

PECTEN (ÆQUIPECTEN) PEXATUS, sp. nov. Plate XXXVI, figs. 5 *a*, *b*, 6, 7 *a*, *b*.

? 1850. PECTEN DUJARDINI, *J. de C. Sowerby*, in *F. Dixon.* Geol. Sussex, p. 356, pl. xxviii, fig. 4 (? locality).

1897. CHLAMYS TERNATA, *H. Woods.* Quart. Journ. Geol. Soc., vol. liii, p. 382 (not the synonymy).

Description.—Shell small, ovate or nearly circular, pointed dorsally, equilateral, and almost equivalve; of slight convexity. Length usually a little less than height. Apical angle about 104°. Ears fairly large.

Both valves have radial folds, of slight elevation, and usually eleven in number. The entire surface is ornamented with numerous narrow, elevated, and sharply limited ribs, which are placed regularly, are of slightly unequal size, and bear many short, hollow spines, which are generally directed ventrally, but are sometimes nearly perpendicular. At the summit of each fold is a rib rather larger than the others, and bearing longer spines; other ribs occur on the sides of the folds, and are introduced at different distances from the umbo, the latest rib being the smallest. On each side of a fold, near the margin of the valve, there are generally three, but sometimes more ribs.

Ears slightly unequal, ornamented with four or more radial spiny ribs, and with a row of spines at the dorsal edge; byssal sinus moderately deep.

Measurements:

	(1)	(2)	(3)	(4)
Length .	24 .	20 .	16·0 .	11·0 mm.
Height .	25 .	20·5 .	16·75 .	11·5 ,,

(1, 3) *H. planus* zone, Cheveley.

(2) Upper Chalk, near Salisbury.

(4) *A. quadratus* zone, East Harnham.

Affinities.—This species resembles *P. asper* (see p. 186), but is much smaller, less convex, with fewer folds (or main ribs), and, in specimens of the same size, with more numerous and more closely placed ribs.

When describing the Mollusca of the Chalk Rock (1897), I referred this species to *P. ternatus*, Goldfuss, which was founded on a cast from the Quader Sandstone of Schandau (Saxony), and appears to be the form usually known as *P. Dujardini*. On further examination this determination did not seem altogether satisfactory, and I have recently, through the kindness of M. Raoul Fortin and M. A. de Grossouvre, received specimens of *P. Dujardini* from France; Professor Deichmüller has also sent me casts of Geinitz' figured specimens. I am now able to say that *P. Dujardini* differs from *P. pexatus* in having much stronger and more distinctly separated folds, with less distinct ribs and spines, and in having closely-placed concentric lamellæ; in specimens larger than those figured by d'Orbigny the ventral margins of the valves are sharply bent. Two of the specimens figured by Geinitz[1] (figs. 10, 11) may belong to *P. pexatus*, but they show the interior of the valves only. *P. Dujardini* appears to be more nearly related to *P. septemplicatus*, Nilsson, than to *P. pexatus*.

Distribution.—Zone of *T. gracilis* of Hooken (Devon). Zone of *H. planus* of Cheveley (Newmarket). Chalk Rock of Winchester and Clothall (Baldock). *Uintacrinus* zone of Devizes Road (Salisbury). Zone of *A. quadratus* of East Harnham. Zone of *B. mucronata* of Clarendon (Salisbury), and of Shute-end Pit, Alderbury.

PECTEN (ÆQUIPECTEN), sp. Plate XXXVI, figs. 8 *a, b*.

Description.—Shell small, flattened, ornamented with from ten to thirteen narrow, elevated ribs, which are separated by broad, flat interspaces. Ribs with hollow, curving spines, placed at regular and fairly distant intervals.

Remarks.—This form, of which I have seen three specimens only, appears to be distinguished from *P. asellus*, Sowerby,[2] by the spines on the ribs. It differs from *P. rarispinus*, Reuss,[3] in the absence of radial folds.

Distribution.—Chalk Rock of Winchester. *A. quadratus* zone of East Harnham (Salisbury) and near Winchester.

[1] 'Das Elbthalgeb. in Sachsen' (1872), pt. 2, pl. x, figs. 10, 11.

[2] J. de C. Sowerby, in F. Dixon, 'Geol. Sussex' (1850), p. 348 (p. 383, ed. 2), pl. xxviii, fig. 5. The locality and horizon of *P. asellus* are not given by Dixon, and the type cannot now be found. I have seen no example which could be referred to this species.

[3] 'Die Verstein. der böhm. Kreideformat.' (1846), pt. 2, p. 31, pl. xxxix, fig. 15; Geinitz, "Das Elbthalgeb. in Sachsen" ('Palæontographica,' 1872, vol. xx, pt. 2), p. 36, pl. x, fig. 13.

PECTEN (ÆQUIPECTEN) SARUMENSIS, sp. nov. Plate XXXVII, figs. 1, 2 *a*, *b*, 3.

Description.—Shell small, slightly inequilateral, height and length nearly equal, outline rounded, convexity small. Apical angle 107° to 111°. Ears rather large.

Right valve ornamented with very numerous (fifty to sixty) narrow, well-marked, radial ribs, which are separated by deep, narrow grooves. The ribs are often slightly unequal, sometimes alternately, the smaller ribs being introduced later than the larger. The ribs bear numerous small, similar, spiny scales, placed either vertically or sloping, and sometimes having a roughly concentric arrangement; near the umbo concentric lamellæ occur. Postero-dorsal margin with fine oblique striæ. Anterior ear long, with a deep sinus and four radial ribs with spines. Posterior ear much shorter, with three or four radial, spiny ribs.

Left valve not seen.

Measurements:

	(1)	(2)	(3)	(4)
Length .	8·5 .	7·0 .	6 .	5·25 mm.
Height .	8·0 .	6·75 .	6 .	5·0 ,,

(1—4) *A. quadratus* zone, East Harnham, Salisbury.

Affinities.—In form this species resembles *P. campaniensis*, but is easily distinguished by the much larger number of ribs. The ornamentation resembles that of *P. pexatus*, but the shell is without radial folds, the ribs are fewer, and the apical angle larger. Radial folds occur on even the smallest specimens of *P. pexatus*.

Types.—In Dr. Blackmore's collection.

Distribution.—*A. quadratus* zone of East Harnham (Salisbury). *B. mucronata* zone of Clarendon (Salisbury).

PECTEN (ÆQUIPECTEN) CAMPANIENSIS, *d'Orbigny*, 1847. Plate XXXVII, figs. 4—8.

1847. PECTEN CAMPANIENSIS, *A. d'Orbigny*. Pal. Franç. Terr. Crét., vol. iii, p. 620, pl. ccccxl, figs. 12—16.

1850. — — — Prodr. de Pal., vol. ii, p. 251.

1870. — — *F. J. Pictet and G. Campiche.* Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 5), p. 215.

1887. — — *A. Peron.* Hist. Terr. Craie S.E. du Bassin Anglo-Parisien (Bull. Soc. Sci. hist. et nat. de l'Yonne, ser. 3, vol. xii), p. 163.

1889. — — *O. Griepenkerl.* Senon von Königslutter (Palaeont. Abhandl., vol. iv), p. 44.

Description.—Shell small, nearly equilateral, nearly circular, length equal to, or slightly greater than the height. Antero- and postero-dorsal margins straightened. Convexity small. Apical angle about 106°. Ears moderately large, unequal.

Right valve with about twenty-four strong, rounded ribs at the margin, some of which may be formed by bifurcation at some distance from the umbo. The ribs may be all of nearly equal size, or those formed by bifurcation may be somewhat smaller and closer together. Grooves between the ribs are deep, but rather narrower than the ribs. Both grooves and ribs are crossed by concentric lamellar ridges, which are especially distinct near the umbo, and may be absent or indistinct ventrally; these ridges are continuous, and placed at regular intervals. Anterior ear long, with a deep sinus, and two or three serrate ribs radiating from its apex and crossed by fine concentric ridges. Posterior ear smaller, triangular, nearly smooth.

Left valve with similar ornamentation, but rather narrower ribs, some of which do not reach the neighbourhood of the umbo. Anterior ear rather long, with three or four well-marked radial ribs crossed by concentric ridges. Posterior ear smaller, with rather less distinct radial ribs and concentric ridges.

Measurements :

	(1)	(2)	(3)	(4)	(5)	(6)	
Length .	11·5 .	9·0 .	7 .	7 .	6 .	5·0	mm.
Height .	11·0 .	8·75 .	7 .	6·75 .	6 .	4·75	,,

(1, 2) *B. mucronata* zone, Norwich.
(3, 6) ,, ,, Clarendon, Salisbury.
(4) *Uintacrinus* zone, Devizes Road, Salisbury.
(5) *A. quadratus* zone, East Harnham, Salisbury.

Affinities.—This species resembles both *P. acute-plicatus*, Alth,[1] and *P. leopoliensis*, Alth,[2] but is distinguished from both by its more numerous ribs, the narrower furrows, and concentric ridges.

Remarks.—This appears to be a rather rare species; I have seen only about a dozen specimens.

Type.—From the Senonian of Chavot (Marne).

Distribution.—*Uintacrinus* zone of Devizes Road, one mile west of Salisbury. *Marsupites* zone near Winchester. *A. quadratus* zone of East Harnham near Salisbury, and Winchester. *B. mucronata* zone of Clarendon near Salisbury, and of Norwich. Upper Chalk of Guildford. Chalk of Trimingham.

[1] Haidinger's 'Naturwiss. Abhand.,' vol. iii, pt. 2 (1850), p. 248, pl. xii, fig. 34; Favre, 'Moll. Foss. Craie de Lemberg' (1869), p. 148, pl. xiii, figs. 3, 4.

[2] Op. cit., p. 247, pl. xii, fig. 33; Favre, op. cit., p. 149, pl. xiii, fig. 5.

PECTEN (ÆQUIPECTEN) ARLESIENSIS, sp. nov. Plate XXXVII, figs. 9—11.

Description.—Shell small, nearly circular, pointed dorsally, height and length nearly equal; nearly equilateral; convexity moderate. Apical angle about 103°. Ears very unequal.

Right valve with fifteen or sixteen strong, rounded, radial ribs, which are undivided, and of nearly equal size, but somewhat smaller anteriorly and posteriorly. Ribs separated by strong, rounded grooves, a little narrower than the ribs. Fine, regularly-placed, concentric ridges cross both ribs and grooves, and are best marked near the umbo; on the ribs they develop into rather prominent, projecting scales. Near the posterior border of the valve the grooves are marked obliquely by closely set striæ. Anterior ear very long, with a deep sinus, and two or three radial ribs bearing scales or tubercles. Posterior ear much shorter, the outer angle approximately rectangular.

Left valve with similar ornamentation, but the ribs rather narrower and the scales somewhat more widely separated.

Measurements:

	(1)	(2)	(3)	(4)
Length .	22 .	9·5 .	7 .	6 mm.
Height .	23 .	9·5 .	7 .	6 ,,

(1, 3, 4) Totternhoe Stone, Arlesey.
(2) Chalk Marl, Folkestone.

Affinities.—This species resembles the form referred by Geinitz (from the Turonian), and by Fritsch, to *P. pulchellus*, Nilsson (see p. 196), but it differs in having fewer and more widely separated ribs. These characters, as well as the scales on the ribs, also separate *P. arlesiensis* from *P. campaniensis*, d'Orbigny.

Types.—From the Chalk Marl of Folkestone.

Distribution.—Chalk Marl of Folkestone, and from a deep boring in the axis of the Winchester anticline. Totternhoe Stone (*H. subglobosus* zone) of Arlesey.

PECTEN (ÆQUIPECTEN) PULCHELLUS, *Nilsson*, 1827. Plate XXXVII, figs. 12 *a*—*c*, 13, 14 *a*, *b*, 15.

1827. PECTEN PULCHELLUS, *S. Nilsson.* Petrific. Suecana, p. 22, pl. ix, fig. 12.
— — LINEATUS, *Nilsson.* Ibid., p. 22, pl. ix, fig. 13.
1833. — SPURIUS, *A. Goldfuss.* Petref. Germ., vol. ii, p. 51, pl. xci, fig. 10.
— — PULCHELLUS, *Goldfuss.* Ibid., p. 51, pl. xci, fig. 9.

1837. Pecten pulchellus, *W. Hisinger.* Lethæa Suecica, p. 51, pl. xvi, fig. 9.

— — lineatus, *Hisinger.* Ibid., p. 51, pl. xvii, fig. 1.

1841. — pulchellus, *F. A. Römer.* Die Verstein. d. nord-deutsch. Kreidegeb., p. 52.

— — spurius, *Römer.* Ibid., p. 52.

1842. — pulchellus, *F. v. Hagenow.* Neues Jahrb. für Min., etc., p. 550.

1847. — — *J. Müller.* Petref. der Aachen. Kreidef., pt. 1, p. 33.

1848. — — *H. G. Bronn.* Index Palæont., vol. i, p. 929.

1850. — — *A. d'Orbigny.* Prodr. de Pal., vol. ii, p. 252.

— — subpulchellus, *d'Orbigny.* Ibid., p. 252.

— — pulchellus, *H. B. Geinitz.* Das Quadersandst. oder Kreidegeb. in Deutschland, p. 184 (*partim*).

— — Staszyci, *A. Alth.* Beschreib. der Umgebung von Lemberg (Haidinger's Naturwiss. Abhandl., vol. iii, pt. 2), p. 248, pl. xii, fig. 35.

1852. — — *R. Kner.* Denkschr. d. k. Akad. Wissensch. Math.-nat. Classe, vol. iii, p. 316, pl. xvii, fig. 2.

1863. — pulchellus, *A. v. Strombeck.* Zeitschr. d. deutsch. geol. Gesellsch., vol. xv, p. 154.

1869. — — *E. Favre.* Moll. Foss. de la Craie de Lemberg, p. 145.

1870. — — *C. Schlüter.* Neues Jahrb. für Min., etc., p. 951.

— — — *F. J. Pictet and G. Campiche.* Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 5), p. 219.

1871 — — *F. Stoliczka.* Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 428.

1889. — — *E. Holzapfel.* Die Mollusk. Aachen. Kreide (Palæontographica, vol. xxxv), p. 234, pl. xxvi, figs. 10—13.

— — — *O. Griepenkerl.* Senon. von Königslutter (Palaeont. Abhandl., vol. iv), p. 45.

— — lineatus, *Griepenkerl.* Ibid., p. 44.

1892. — (Chlamys) pulchellus, *E. Stolley.* Die Kreide Schleswig-Holsteins (Mittheil. Min. Institut. Univers. Kiel, vol. i), p. 240.

1895. — pulchellus, *F. Vogel.* Holländisch. Kreide, p. 23.

— — spurius, *Vogel.* Ibid., p. 22, pl. i, figs. 20, 21.

1897. — pulchellus, *A. Hennig.* Revis. Lamell. i Nilsson's 'Petrif. Suecana' (Kon. Fysiogr. Sällsk. i Lund. Handl., N. F., vol. viii), p. 33, pl. ii, figs. 27, 29—32; pl. iii, figs. 1, 2.

1900. — (Æquipecten) pulchellus, *E. Philippi.* Zeitschr. d. deutsch. geol. Gesellsch., vol. lii, p. 101, fig. 18.

1902. — pulchellus, *J. P. J. Ravn.* Mollusk. i Danmarks Kridtafl. I. Lamellibr. (Kgl. Danske Vid. Selsk. Skrift. 6 Række, nat. math. Afd., vol. xi), p. 82, pl. i, fig. 8.

Non 1842. Pecten pulchellus, *P. Matheron.* Cat. Foss. du Bouches-du-Rhône, p. 186, pl. xxx, figs. 4—6.
— 1853. — — *L. Reeve.* Conch. Iconica, vol. viii, pl. xxxii, fig. 142.
— 1872. — — *H. B. Geinitz.* Das Elbthalgeb. in Sachsen (Palæontographica, vol. xx, pt. 2), p. 33, pl. x, figs. 2—4.
— 1877. — — *A. Fritsch.* Stud. im Gebiete der böhm. Kreideformat.: II, Die Weissenberg. u. Malnitz. Schicht., p. 136, fig. 130.
— 1893. — — *R. Michael.* Zeitschr. d. deutsch. geol. Gesellsch., vol. xlv, p. 243.

Description.—Shell small, oval, rounded, height equal to, or slightly greater than the length; nearly equilateral, the postero-dorsal margin a little longer than the antero-dorsal. Convexity of valves small. Apical angle about 103°. Ears of moderate size, unequal.

Right valve with a variable number (twenty-three to forty-four at the margin) of broad, flattened, radial ribs, separated by much narrower, shallow grooves; in approaching the umbo some of the ribs become united in pairs. Near the anterior and posterior borders ribs are small or absent. Both ribs and grooves are marked by numerous fine radial striæ, which, in the middle of the valve, are parallel with the ribs, but cut them more and more obliquely in passing toward the anterior and posterior margins, which they meet at acute angles. Anterior ear longer than high, with the outer margin rounded and a rather small sinus; posterior ear smaller, triangular, higher than long, outer angle obtuse; both ears with radial striæ like those on the valve, and the anterior ear sometimes with a few concentric ridges also.

Left valve with narrow, elevated, sharply-limited ribs, some of which (often alternate ones) do not reach the neighbourhood of the umbo. Ribs small or absent near the anterior and posterior margins. Grooves between the ribs broad and deep, marked by radial striæ like those on the right valve. Summits of ribs slightly serrate. Ears triangular, the posterior a little smaller than the anterior and with the outer angle obtuse; both ears with radial striæ.

Measurements:

	(1)	(2)	(3)	(4)
Length	20·5	15·0	12·5	10·5 mm.
Height	20·5	16·0	13·0	11·0 ,,

(1—4) from Trimingham.

Affinities.—*P. lineatus*, Nilsson, is a left valve of *P. pulchellus*. *P. spurius*, Goldfuss, from Haldem, of which the type is in the Munich Museum, has been shown by Hennig to be identical with *P. pulchellus*. The form from the Plänerkalk of Strehlen referred by Geinitz to *P. pulchellus* is regarded by Schlüter,

PLATE XXVII.

Genus—PECTEN, *Müller*.

Pecten (*Syncyclonema*) *orbicularis*, Sow. (P. 145.)

(All in the Woodwardian Museum, except fig. 4.)

FIGS.

1, 2. Tealby Limestone, North Willingham. Right valves.

3. Gault, Folkestone, Wiltshire Collection. Right valve.

4. Var. *haldonensis*, Woods. Upper Greensand, Kingskerswell. Museum of Practical Geology, No. 991. Right valve.

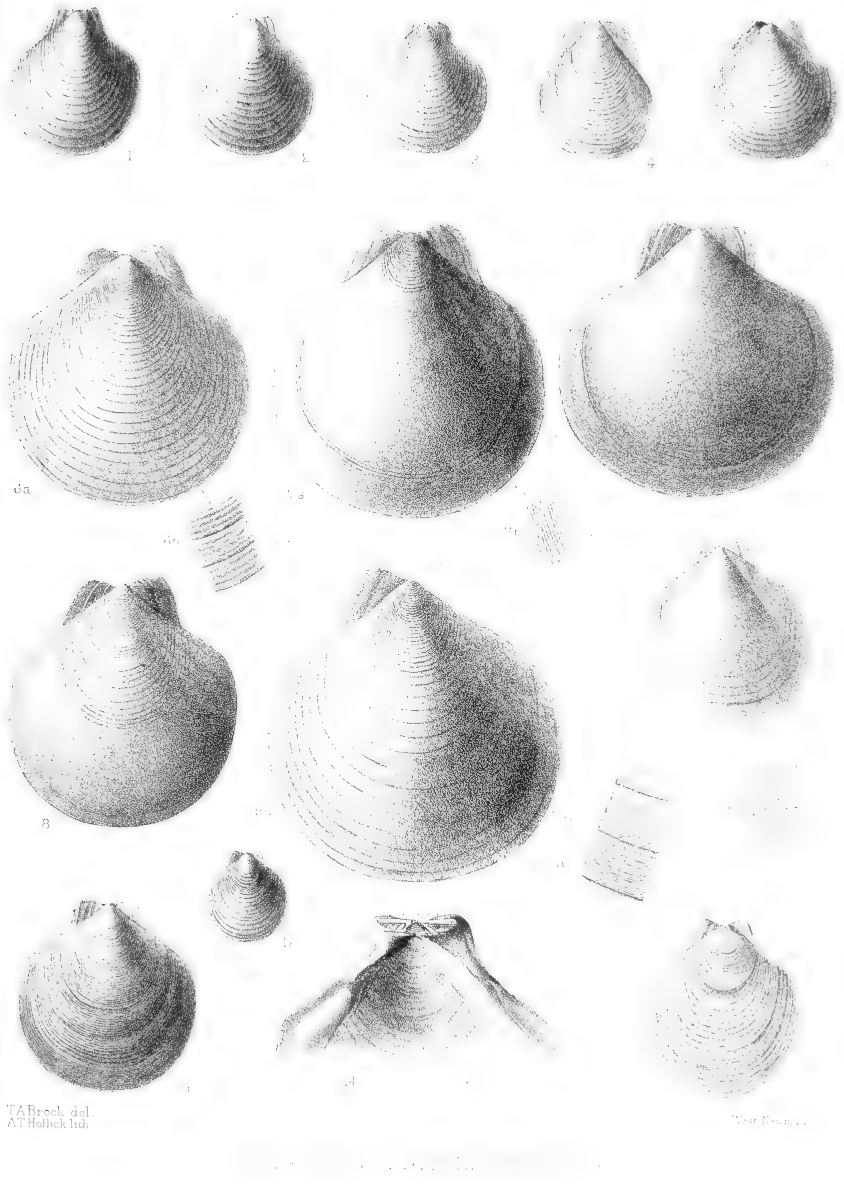
5. Chloritic Marl, Maiden Bradley. Right valve.

6—9. Upper Greensand, Ventnor. 6 *a*, right valve (ears partly drawn from another specimen); 6 *b*, antero-ventral portion of the same × 3. 7 *a*, right valve (margins of ears slightly restored); 7 *b*, posterior portion of the same × 3; 7 *c*, left valve of the same specimen. 8, right valve. 9 *a*, right valve; 9 *b*, postero-ventral portion of the same × 3. 6, 7, Leckenby Collection. 8, 9, Wiltshire Collection.

10—13. Chalk Marl, Burwell. 10 *a*, left valve; 10 *b*, portion of the same near the ventral margin × 10 (on other parts of the valve the fine concentric ridges are closer together). 11—13, right valves.

14. Totternhoe Stone, Burwell. Part of interior of right valve × 2.

PLATE XXVII.



T.A.Brock del.
A.T.Hollick lith.

West Newm...

PLATE XXVIII.

PECTEN (*continued*).

P. (*Camptonectes*) *cinctus*, Sow. Claxby Ironstone (zone of *B. lateralis*) of Claxby. Woodwardian Museum. (P. 152.)

FIGS.

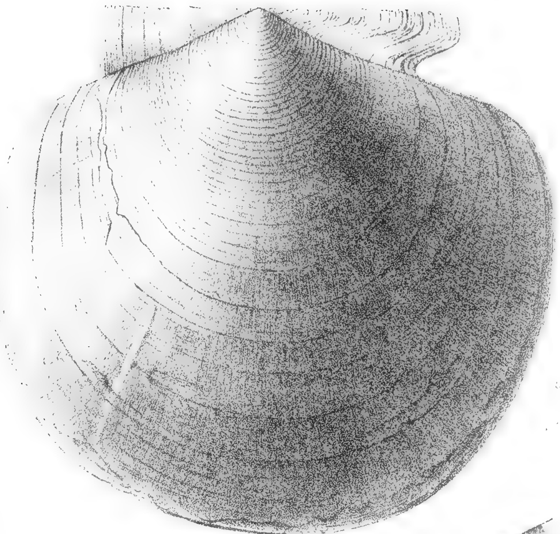
1 *a*. Right valve × $\frac{1}{2}$. 1 *b*, portion of the same, natural size.

2 *a*. Left valve of another specimen × $\frac{2}{3}$. 2 *b*, portion of the same, natural size.

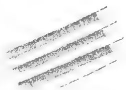
3. Portion of left valve with the concentric laminæ well preserved × 2.

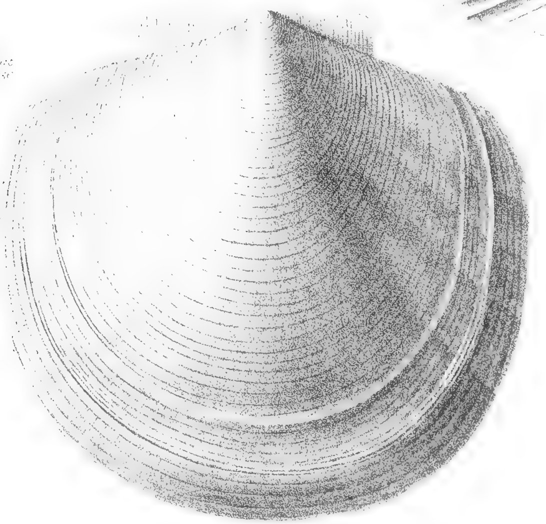
(The ears in figs. 1 *a*, 2 *a*, have been partly completed from other specimens.)

PLATE XXVIII.



1b





TABrock del.
ATHollick lith.

CRETACEOUS LAMELLIBRANCHIA

PLATE XXIX.

Pecten (*continued*).

Figs.

1—3. *P.* (*Camptonectes*) *Cottaldinus*, d'Orb. Leckenby Collection, Woodwardian Museum. (P. 156.)

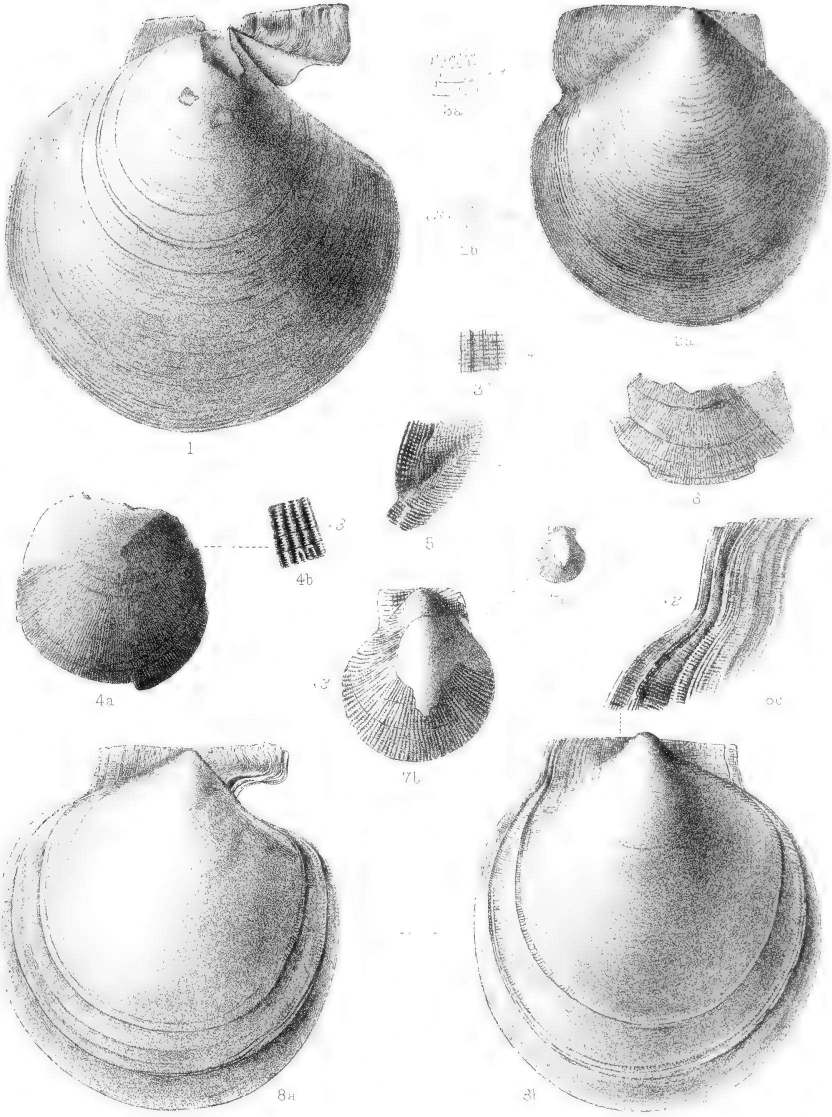
1. Lower Greensand, Whale Chine. Right valve.
2. *Perna*-bed, Atherfield. *a*, left valve; *b*, part of the same above the middle of the valve × 3.
3. *Perna*-bed, Atherfield. Left valve. *a*, part near the middle of the dorsal third × 3; *b*, part of the anterior ear × 4.

4—6. *P.* (*Camptonectes*) *striato-punctatus*, Röm. (P. 157.)

4. Speeton Clay (D 1). Mr. Lamplugh's Collection. *a*, part of left valve; *b*, part of same × 3.
5. Same horizon, etc. Anterior left ear × 3.
6. Claxby Ironstone, Benniworth Haven. Woodwardian Museum. Part of left valve.

7. *P.* (*Camptonectes*) *curvatus*, Gein. Greensand, Great Haldon. Museum of Practical Geology, No. R 478*a*. Left valve. *a*, natural size; *b*, same × 3. (P. 159.)

8. *P.* (*Camptonectes*) *dubrisiensis*, Woods. Chalk Marl, Dover. British Museum, No. 38243. *a*, right valve; *b*, left valve; *c*, anterior ear of *b* × 2. (P. 162.)



T A Brock del.
A T. Hollick lith.

West, Newman

CRETACEOUS LAMELLIBRANCHIA

PLATE XXX.

PECTEN (*continued*).

FIGS.

1, 2. *P.* (*Camptonectes?*) *gaultinus*, Woods. Gault. Woodwardian Museum. 1 *a*, right valve, Folkestone, × $1\frac{1}{2}$; 1 *b*, portion of the same near the postero-dorsal margin × 6. 2, left valve, Black Ven, × 2. (P. 163.)

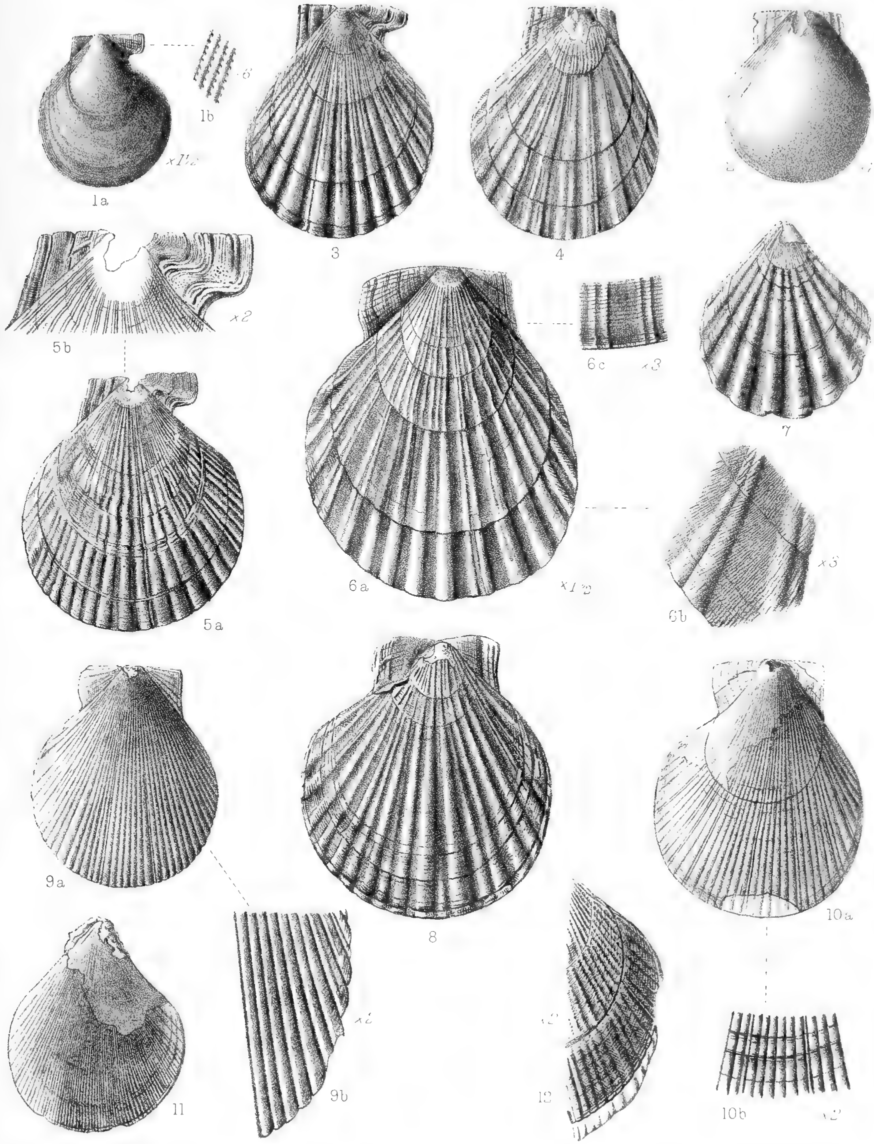
3—8. *P.* (*Chlamys*) *fissicosta*, Eth. Woodwardian Museum. (P. 163.)

3—6. Totternhoe Stone, Burwell.
7. ,, ,, Arlesey.
8. ,, ,, Cherry Hinton.

3, right valve (type). 4, left valve (type). 5 *a*, right valve; 5 *b*, part of the same specimen × 2. 6 *a*, left valve × $1\frac{1}{2}$; 6 *b*, part of the same near the antero-ventral border × 3; 6 *c*, another part near the middle of the valve × 3. 7, right valve of a variety with few ribs. 8, left valve, crushed near the umbo.

9—12. *P.* (*Chlamys*) *Puzosianus*, Math. Woodwardian Museum. (P. 165.)

9. Cenomanian, north of Beer Head. *a*, left valve; *b*, postero-ventral part of the same × 2.
10. Cenomanian, Wilmington. *a*, left valve; *b*, part of the same near the centre × 2.
11. Same locality. Right valve.
12. Top of Chloritic Marl, Melbury, North Dorset. Anterior part of right valve with the ornamentation well preserved × 2.



T.A.Brock del.
A.T.Hollick lith.

West, Newman imp.

CRETACEOUS LAMELLIBRANCHIA.

PLATE XXXI.

Pecten (*continued*).

Figs.

1, 2. *P.* (*Chlamys*) *britannicus*, Woods. (P. 167.)

1. Dr. Blackmore's Collection. Upper part of *M. cor-anguinum* zone, Stratford, near Salisbury. *a*, part of valve; *b*, same × 4.
2. Mr. G. E. Dibley's Collection. *M. cor-anguinum* zone, Haling Pit, South Croydon. *a*, left valve; *b*, part of the same × 3.

3—6. *P.* (*Chlamys*) *Milleri*, Sow. Greensand, Blackdown. Woodwardian Museum. (P. 168.)

3. Meÿer Collection. *a*, left valve; *b*, part of the same near the umbo × 6.
4. Wiltshire Collection. *a*, right valve × 2. The anterior ear is drawn from another specimen in the same collection.
5. Wiltshire Collection. Right valve. Ornamentation just above the middle of the valve × 6.
6. Meÿer Collection. *a*, left valve; *b*, postero-ventral part of the same × 3.

7—9. *P.* (*Chlamys*) *subacutus*, Lam. (P. 169.)

7, 9. Meÿer Collection. Bed 11 (Cenomanian), Dunscombe. 7 *a*, right valve; 7 *b*, part of same × 3. 9, ribs of another right valve near the middle of the valve × 3.

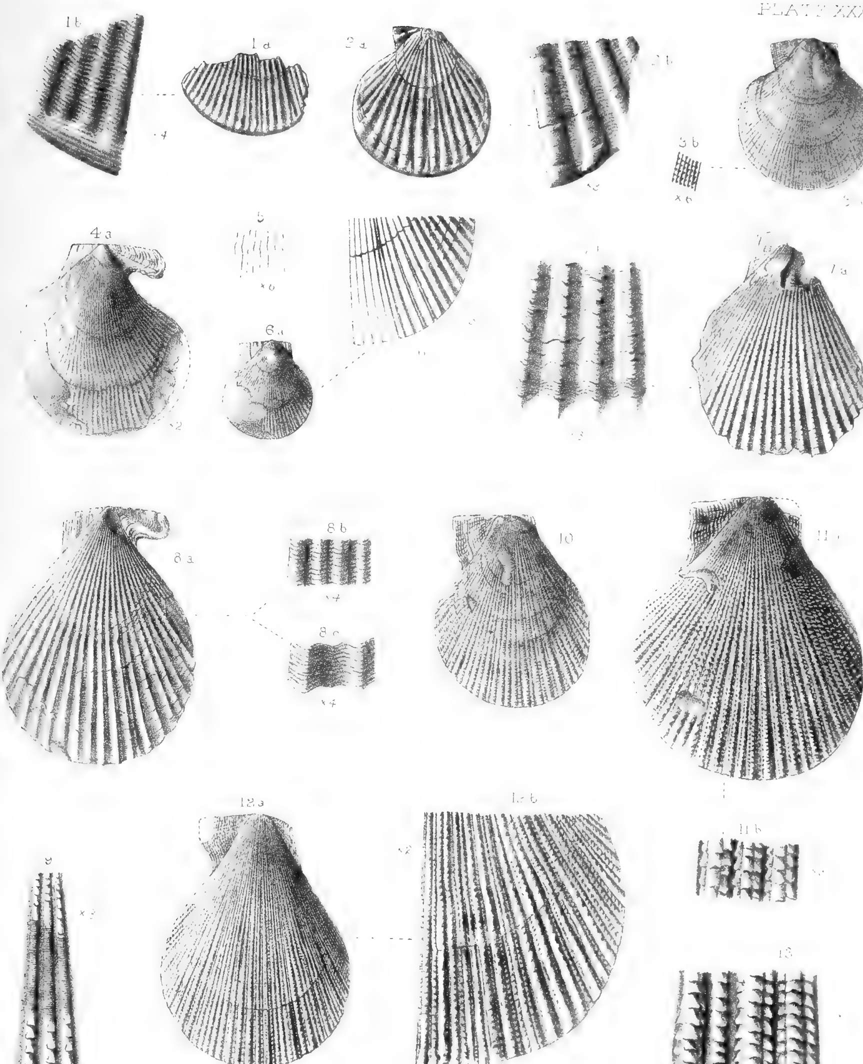
8. Museum of Practical Geology, No. 6683. Greensand, Haldon. *a*, right valve; *b*, part of same in the middle of the dorsal third × 4; *c*, part near middle of ventral border × 4.

10—13. *P.* (*Chlamys*) *elongatus*, Lam. Woodwardian Museum. (P. 170.)

10, 11. Wiltshire Collection. Gault, Folkestone. 10, left valve. 11 *a*, left valve; 11 *b*, part of same × 3.

12. Wiltshire Collection. Chalk Marl, Ventnor. *a*, left valve; *b*, postero-ventral part of same × 2.
13. Totternhoe Stone, Arlesey. Right valve. Ribs near the middle of the ventral border × 4.

PLATE XXXI.



T.A.Brock del.
A.T.Hollick lith.

West Newman

CRETACEOUS LAMELLIBRANCHIA

PLATE XXXII.

PECTEN (*continued*).

FIGS.

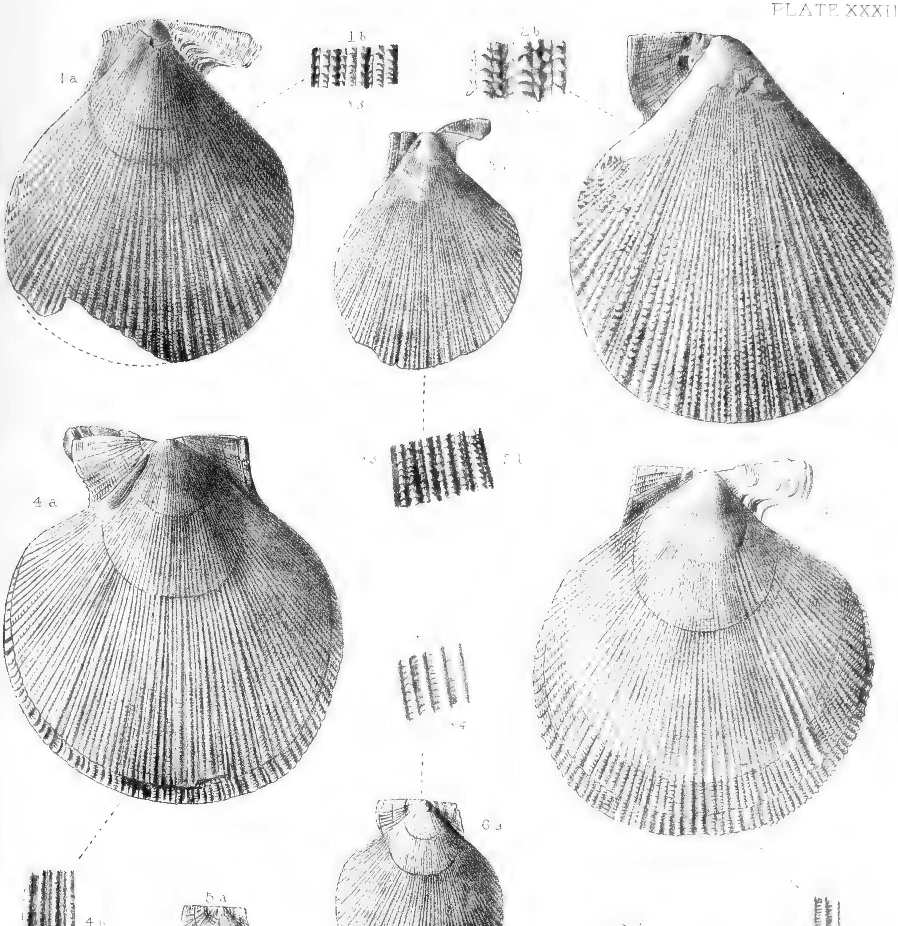
1—3. *P.* (*Chlamys*) *elongatus*, Lam. (P. 170.)

1. Grey Chalk, Dover. York Museum. *a*, right valve; *b*, portion of the same near the middle of the valve × 3.
2. Lower Chalk, Burwell. Woodwardian Museum. *a*, left valve; *b*, part of the same near the middle of the valve × 3.
3. Same horizon, etc. *a*, right valve; *b*, part of same below the middle of the valve × 3. (The anterior ear is displaced.)

4—6. *P.* (*Chlamys*) *cretosus*, Defr. *A. quadratus* zone, East Harnham. Dr. Blackmore's Collection. (P. 174.)

4 *a*, left valve × $1\frac{1}{2}$.
4 *b*, mid-ventral ribs of 4 *a* × 3.
4 *c*, right valve of the same specimen × $1\frac{1}{2}$.
4 *d*, mid-ventral ribs of 4 *c* × 3.
5 *a*, left valve.
5 *b*, part of 5 *a* posterior to the middle of the ventral border × 4.
6 *a*, left valve.
6 *b*, umbo of 6 *a* × 3.
6 *c*, part of 6 *a* near the mid-ventral border × 4.

PLATE XXXII



T.A.Brock del.
A.T.Hollick lith.

CRETACEOUS LAMELLIBRANCHIA

PLATE XXXIII.

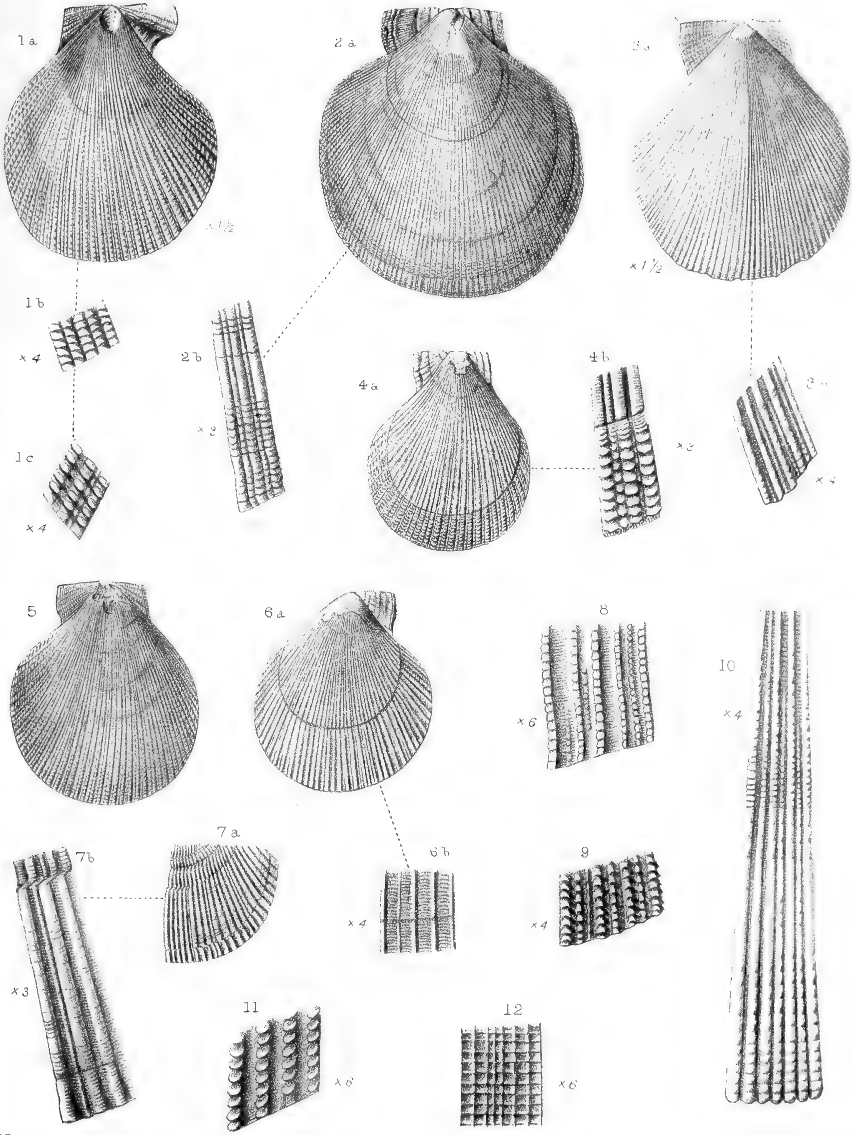
PECTEN (*continued*).

Pecten (*Chlamys*) *cretosus*, Defr. Upper Chalk. (P. 174.)

FIGS.

1. *A. quadratus* zone, East Harnham. Dr. Blackmore's Collection. *a*, right valve × $1\frac{1}{2}$; *b*, part at antero-ventral edge × 4; *c*, antero-ventral part of left valve of the same specimen × 4.
2. Same horizon, etc. *a*, left valve; *b*, part just behind the mid-ventral edge × 3.
3. Same horizon, etc. *a*, left valve × $1\frac{1}{2}$; *b*, part at postero-ventral margin × 4. Fine concentric ridges cover almost the entire shell, but are not shown in the figure. Near the umbo the radial ribs are spiny.
4. *M. cor-anguinum* zone, Porton. Dr. Blackmore's Collection. *a*, left valve; *b*, part just behind the mid-ventral margin × 3.
5. *Marsupites* zone, Witherington. Dr. Blackmore's Collection. Left valve.
6. *M. cor-anguinum* zone, Gravesend. Mr. G. E. Dibley's Collection. *a*, right valve, with interior of anterior *left* ear; *b*, part of mid-ventral third × 4.
7. Upper Chalk, Bromley. Wiltshire Collection. Right valve of specimen with coarse ribs. *a*, antero-ventral part; *b*, portion of same part × 3.
8. Same horizon, etc. Part of mid-ventral third of left valve × 6.
9. *B. mucronata* zone, Norwich. Norwich Museum, No. 2056. Part of left valve near the middle of the ventral edge × 4.
10. *A. quadratus* zone, East Harnham. Dr. Blackmore's Collection. Part at the mid-ventral edge × 4.
11. Upper Chalk, Charlton. Wiltshire Collection. Right valve of a specimen with the scaly spines large and well-preserved. Part near the ventral edge × 6.
12. Upper Chalk, Trimingham. Mr. R. M. Brydone's Collection. Right valve. Form with numerous slender ribs. Portion at the dorsal third × 6.

PLATE XXXIII.



T.A.Brock del.
A.T.Hollick lith.

West.Newman imp.

CRETACEOUS LAMELLIBRANCHIA.

PLATE XXXIV.

Pecten (*continued*).

Figs.

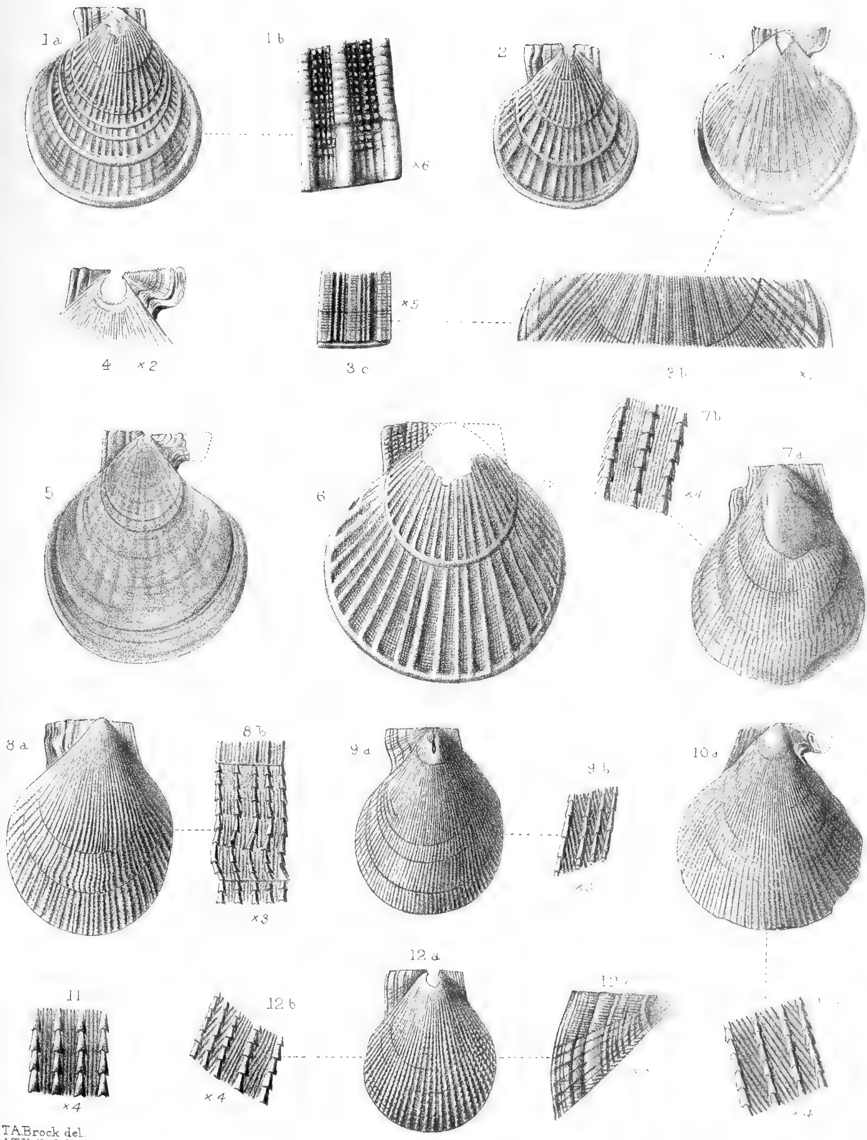
1—6. *P.* (*Chlamys*) *Mantellianus*, d'Orb. Upper Chalk (*B. mucronata* zone), Norwich. Norwich Museum (except fig. 3). (P. 179.)

1. No. 2093. *a*, left valve; *b*, part near mid-ventral edge × 6.
2. No. 2053. Left valve.
3. Woodwardian Museum. Right valve. *a*, natural size; *b*, middle part × 2; *c*, portion near the centre × 5.
4. No. 2055. Right valve. Part near the umbo × 2.
5. No. 2055 (another specimen). Right valve.
6. No. 2053. Left valve × 2.

7—12. *P.* (*Chlamys*) *Robinaldinus*, d'Orb. *Perna*-bed. Atherfield. Woodwardian Museum. (P. 181.)

7. Leckenby Collection. *a*, left valve; *b*, part near the margin just in front of the mid-ventral part × 4.
8. Leckenby Collection. *a*, left valve; *b*, part of the middle of the valve between the two strong growth-lines × 3.
9. Leckenby Collection. *a*, left valve; *b*, part near the mid-ventral edge × 3.
10. *a*, right valve; *b*, part near the antero-ventral margin × 4.
11. Left valve; middle of ventral third × 4.
12. Wiltshire Collection. *a*, left valve; *b*, part near the mid-ventral margin × 4; *c*, anterior ear × 3.

PLATE XXXIV.



T.A.Brock del.
A.T.Hollick lith.

West, Newman imp.

CRETACEOUS LAMELLIBRANCHIA

PLATE XXXV.

PECTEN (*continued*).

FIGS.

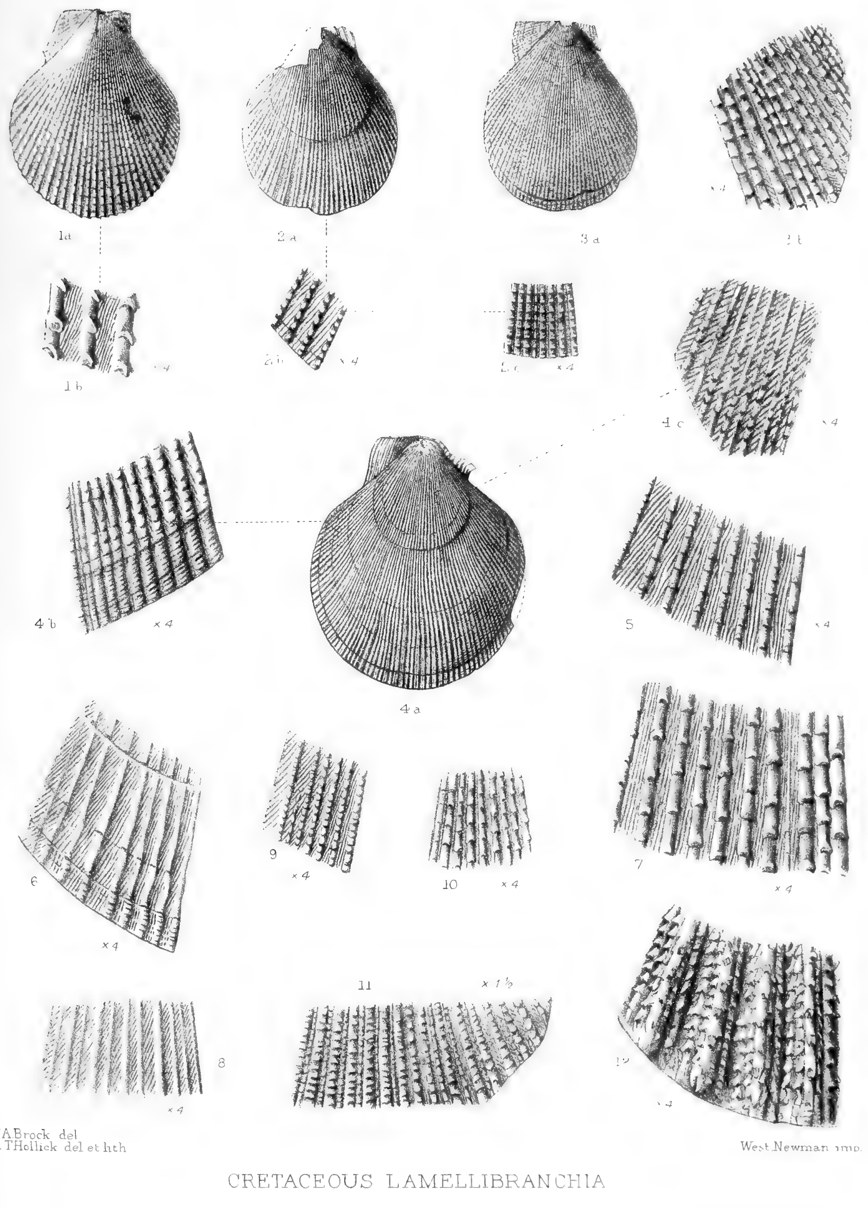
1—10. *P.* (*Chlamys*) *Robinaldinus*, d'Orb. Upper Greensand (except figs. 5, 6, 8). (P. 181.)

1. Warminster. British Museum, No. 67734. *a*, left valve; *b*, antero-ventral part of the same × 4.
2. Warminster. Woodwardian Museum. *a*, left valve; *b*, antero-ventral part × 4; *c*, part near the umbo × 4.
3. Ventnor. Wiltshire Collection. *a*, left valve; *b*, posterior part × 4.
4. Warminster. Museum of Practical Geology, No. 7418. *a*, right valve; *b*, part just in front of the mid-ventral edge × 4; *c*, anterior part of left valve of same specimen × 4.
5. Chloritic Marl, Maiden Bradley. Mr. J. Scanes' Collection. ? Left valve; antero-ventral part × 4.
6. Same horizon, etc. Left valve; part at the antero-ventral margin × 4.
7. Ventnor. Wiltshire Collection. Left valve; mid-ventral part × 4.
8. Cenomanian (Bed 11), Beer Head. Meÿer Collection. ? Left valve; antero-ventral part × 4.
9. Warminster. Bristol Museum. Right valve; postero-ventral part × 4.
10. Warminster. Museum of Practical Geology, No. 7407. Middle part of left valve × 4.

11. *P.* (*Chlamys*) *Stutchburianus*, Sow. Greensand, Blackdown. The Type. Bristol Museum. Ventral part × $1\frac{1}{2}$. (P. 185.)

12. *P.* (*Æquipecten*) *asper*, Lam. Upper Greensand (Chert Beds), Baycliffe Quarry, Wiltshire. Mr. J. Scanes' Collection. Left valve; part just in front of mid-ventral margin × 4. (P. 186.)

PLATE XXXV



T.A.Brock del.
A.T.Hollick del et lith.

West, Newman imp.

CRETACEOUS LAMELLIBRANCHIA

PLATE XXXVI.

PECTEN (*continued*).

FIGS.

1—4. *P.* (*Æquipecten*) *asper*, Lam. Upper Greensand, Warminster. (P. 186.)

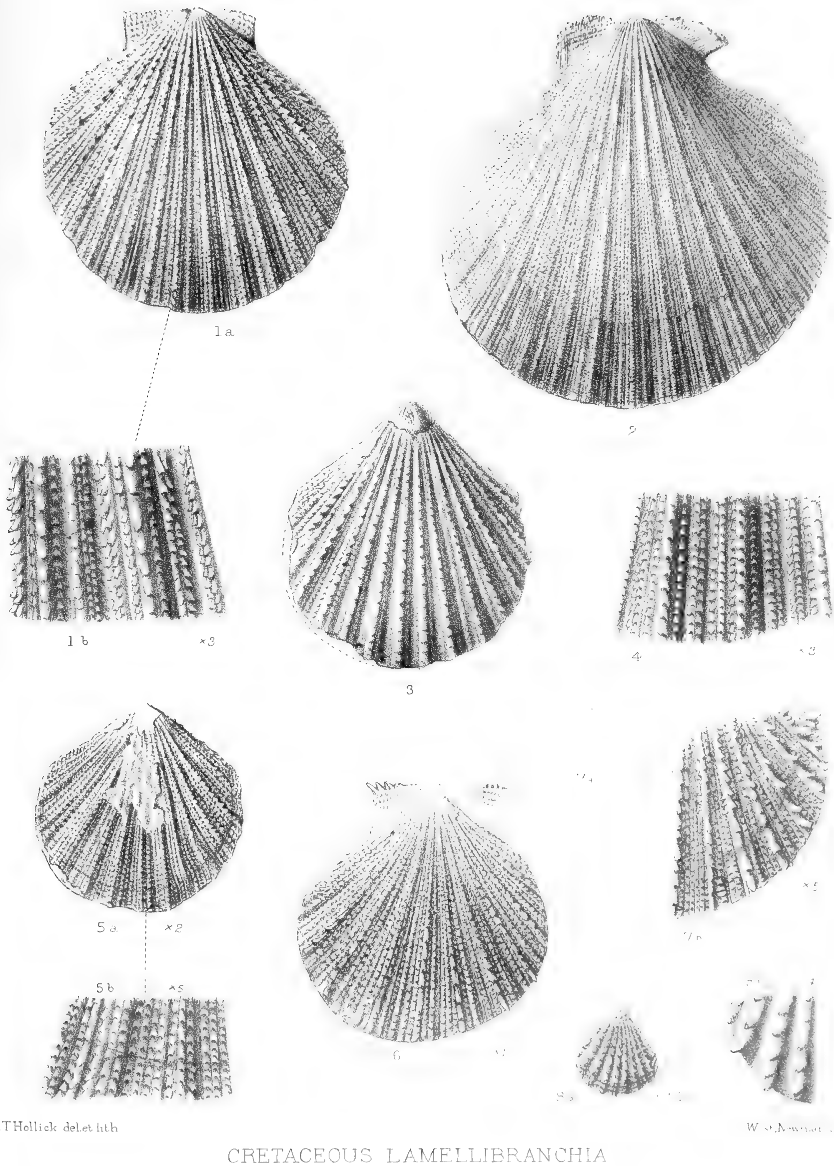
1. Woodwardian Museum. *a*, left valve (the anterior ear is drawn from another specimen); *b*, ventral part × 3.
2. York Museum. Right valve.
3. Woodwardian Museum. A form with few ribs. ? Right valve.
4. Woodwardian Museum. Right valve; mid-ventral part × 3.

5—7. *P.* (*Æquipecten*) *pexatus*, Woods. (P. 190.)

5. Upper Chalk, near Salisbury. Dr. Blackmore's Collection. *a*, × 2; *b*, ventral part × 5.
6. *H. planus* zone, Cheveley, near Newmarket. Woodwardian Museum. × 2.
7. *A. quadratus* zone, East Harnham. Dr. Blackmore's Collection. *a*, outline, natural size; *b*, part of same × 5.

8. *P.* (*Æquipecten*), sp. *A. quadratus* zone, East Harnham. Dr. Blackmore's Collection. *a*, × $1\frac{1}{2}$; *b*, part of same × 4. (P. 191.)

PLATE XXXVI



A T Hollick del.et lith

CRETACEOUS LAMELLIBRANCHIA

PLATE XXXVII.

PECTEN (*continued*).

FIGS.

1—3. *P.* (*Æquipecten*) *sarumensis*, Woods. *A. quadratus* zone, East Harnham, Salisbury. Dr. Blackmore's Collection. Right valves. 1 *a*, × 4; 1 *b*, antero-ventral portion × 8. 2 *a*, × 4; 2 *b*, anterior part of *a* × 6. 3, × 4. (P. 192.)

4—8. *P.* (*Æquipecten*) *campaniensis*, d'Orb. (P. 192.)

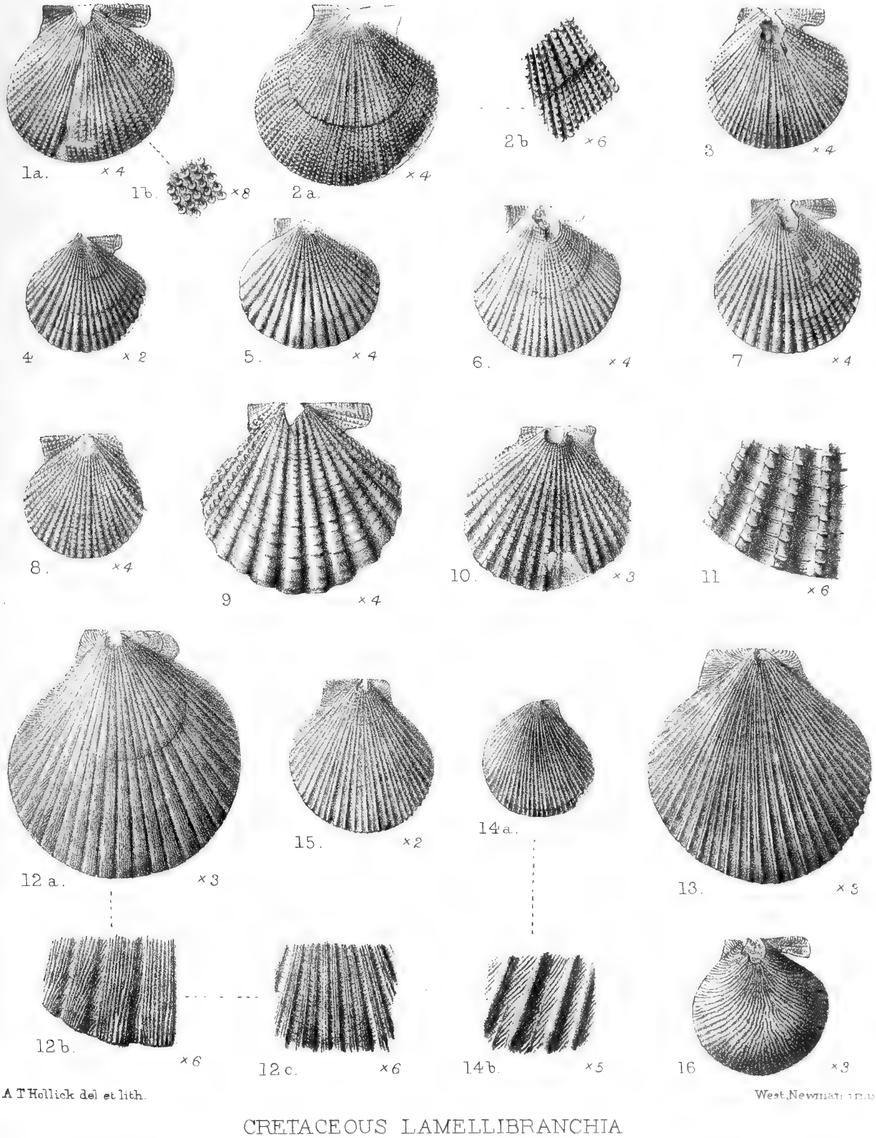
4. Norwich Museum, No. 2044. *B. mucronata* zone, Norwich. Right valve × 2.
5. Dr. Blackmore's Collection. *Uintacrinus* zone, Devizes Road, Salisbury. Right valve × 4.
6, 7. Same Collection. *B. mucronata* zone, Clarendon, near Salisbury. Right valves. 6, × 4. 7, × 4.
8. Same Collection. *A. quadratus* zone, East Harnham. Left valve × 4.

9—11. *P.* (*Æquipecten*) *arlesiensis*, Woods. Chalk Marl, Folkestone. 9, Wiltshire Collection, Woodwardian Museum. Right valve × 4. 10, Museum of Practical Geology, No. 562. Left valve × 3. 11, Same Museum, No. 562. Left valve; mid-ventral part × 6. (P. 194.)

12—15. *P.* (*Æquipecten*) *pulchellus*, Nilss. Upper Chalk, Trimingham. (P. 194.)

12. Museum of Practical Geology, No. 8013 (collected by Mr. C. Reid). *a*, right valve × 3; *b*, ventral part of the same × 6; *c*, part of dorsal third × 6.
13—15. Mr. R. M. Brydone's Collection. Left valves. 13, × 3. 14 *a*, natural size; 14 *b*, part near the antero-ventral margin × 5. 15, × 2.

16. *P.* (*Camptonectes*) *curvatus*, Gein. Chloritic Marl, Eastbourne. Woodwardian Museum. Right valve × 3. (P. 159.)



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CRETACEOUS LAMELLIBRANCHIA

PLATE XXXVIII.

PECTEN (*continued*).

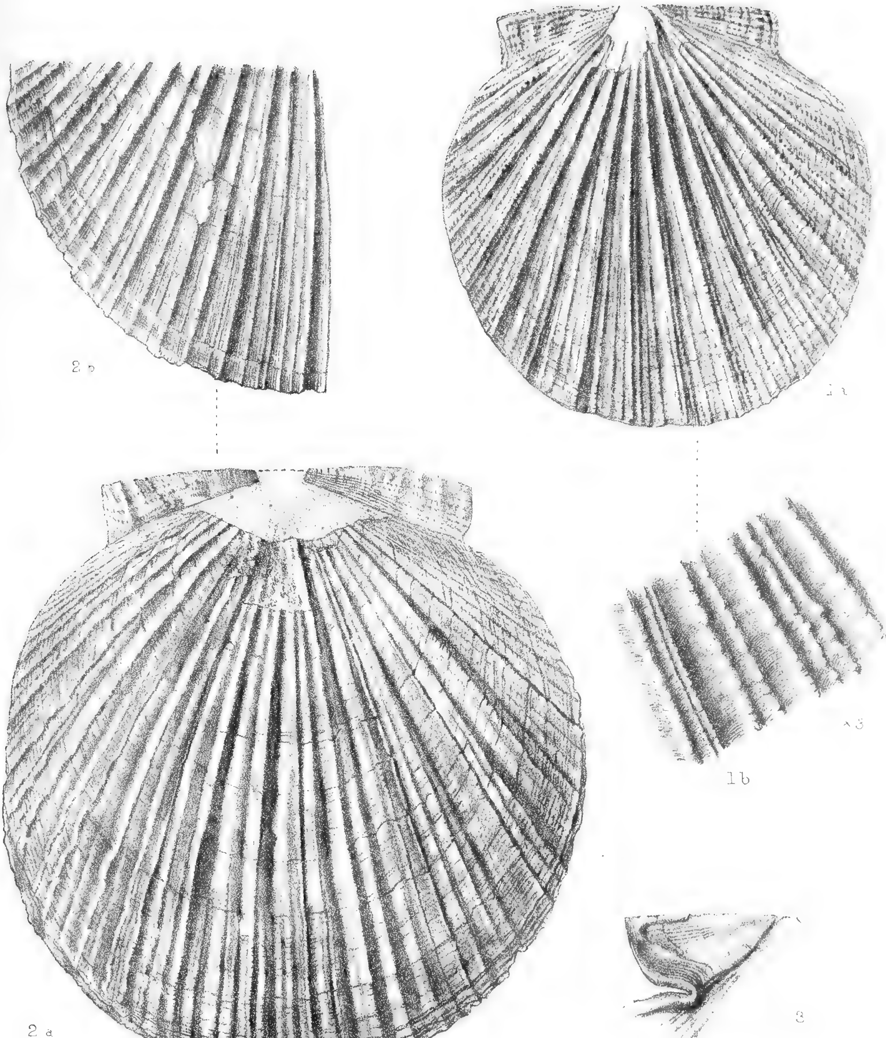
P. (*Æquipecten*) *Beaveri*, Sow. (P. 188.)

FIGS.

1. Chalk Marl, Dover. York Museum. *a*, left valve; *b*, posterior portion × 3.

2. *H. subglobosus* zone, Shelford Lime-kiln, Gog-ma-gog Hill. Woodwardian Museum. *a*, right valve (the ears are drawn from another specimen); *b*, antero-ventral portion of left valve of the same specimen.

3. *H. subglobosus* zone, Cherry Hinton. Woodwardian Museum. Interior of part of right valve, showing byssal sinus.



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CRETACEOUS LAMELLIBRANCHIA.

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OF

BRITISH GRAPTOLITES.

BY

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AND

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INTRODUCTION.

PAGES i–xxviii.

PART I.—DICHOGRAPTIDÆ.

PAGES 55–102; PLATES V–XIII.

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BRITISH GRAPTOLITES.

HISTORY OF RESEARCH.

The History of Research among Graptolites commences in the early years of the eighteenth century. Examples of these fossils were first noticed in the works of von Bromell about 1727, and a few years later the name *Graptolithus* was first suggested by Linnæus in his 'Systema Naturæ.'

The History itself falls conveniently into four periods. In the first of these (1727 to 1850) papers upon Graptolites were comparatively rare, and their authors did little more than figure and describe the forms which they collected. During the second period (1850 to 1865) the brilliant papers of Barrande in Europe and Hall in America called universal attention to the abundance and variety of Graptolites in the older Palæozoic rocks, and these authors laid the foundation of our present ideas respecting their structure and their alliances. During the third period (1866 to 1880) the workers among these fossils were largely British, who devoted themselves firstly to the investigation and description of the British species and the determination of their geological horizons; and secondly to the discussion of the problems of the classification, zonal distribution, and probable mode of life of the Graptolites in general. Finally, during the fourth period (reaching from 1881 down to the present time) the workers among Graptolites have been mainly non-British, especially Swedish, and the advances made have been great, particularly as respects the intimate structure of the fossils themselves, their distribution in space and in time, and their probable conditions of existence.

A separate chapter is here devoted to each of these four periods. The publications of the several investigators are taken up in chronological sequence, and each generic or specific title when proposed or employed for the first time is distinguished by being printed in clarendon type.

CHAPTER I.

First Period, 1727 to 1850.

1727.
Von Bromell,
"Lithographiæ Suecanæ,"
'Acta literaria Sueciæ Upsaliæ,' vols. i, ii, 1720–9.

There seems but little doubt that Magnus von Bromell, of Upsala, Sweden, must be credited with the first notice and description of the fossils which we now call Graptolites, although he did not use the word "Graptolithus," nor did he give figures of these fossils. In the years 1720–9 he brought out his work entitled "Lithographiæ Suecanæ." In this he gives, among other things, a description of a collection of fossils belonging to himself. This work was published in the 'Acta literaria Sueciæ Upsaliæ' (1720–9), and also separately in two parts, the *Specimen primum* in 1724, and the *Specimen secundum* in 1727.

In the *Specimen primum* there is no reference which can be considered as applying to Graptolites; but in the *Specimen secundum* the *Articulus primus* is entitled "Concerning a moss incrusted and delineated in stone." The example No. 1 given in this section is described as "a rock of ashy colour, fissile, fœtid, called 'Swinestone' (lapis suillus), exhibiting on the surface a black tangle of branched moss imprinted as with a fine pencil. . . . . The moss which is seen delineated on the above-mentioned rock is of a stony nature, hair-like, not penetrating the actual substance of the rock—as one can see in some of the Florentine and German dendrites,—but spreading its delicate form on the outermost surface."

Tullberg, to whose valuable memoir, "On the Graptolites described by Hisinger and the older Swedish Authors," 'K. Svenska Vet. Akad. Handl.,' 1882, we are especially indebted, remarks that von Bromell elsewhere uses the term "lapis suillus" for real anthraconite or swinestone (concretions occurring in the alum shales of Sweden), and it may therefore be inferred with fair certainty that he refers to that rock in this case. If so, the fossil which von Bromell describes as a "branched moss," and compares with a dendrite, is probably the *Dictyonema flabelliforme* of Eichwald, a fossil which frequently occurs in the balls of anthraconite in the alum shales of Westrogothia.

Von Bromell's *Articulus secundus* is headed "Concerning the imprints and remains of leaves in various rocks." Example 3 in this section is described as "Leafy impressions and traces of different plants in a black fissile rock from Mt. Dalaberg in Westrogothia;" and the author remarks, "The true names of these leaves I cannot at present state; for while some, by their pinnules, seem to recall ferns, others by their narrowness and length a kind of grass, some by their pointedness and tenuity a willow, others the heather and small water-lily, yet I

dare not decide precisely to what they belong until I have received more and better specimens."

These observations of von Bromell are mentioned by Wahlenberg and later writers, who are of the opinion that the rock referred to was a shale containing Graptolites. Wahlenberg remarks that "when the shale is of a bluish or bluish-grey colour, the pictures of *Graptolithus* appear black, and at the same time their outlines so blend among themselves that their full figures appear only linear, and these Bromell took for leaves of grasses."

1735.
Linnæus,
'Systema Naturæ,'
edit. 1.

The great systematist, Linnæus, was the second to notice and describe examples of Graptolites; and we owe to him the title *Graptolithus*, which was subsequently adopted as the name of the genus that eventually became accepted as the type of the entire group. In the first edition of his 'Systema Naturæ,' section "Regnum lapideum," Classis III, Fossilia, he defines his third order as follows:—"**Graptolithus**, picture resembling a fossil." It would appear, therefore, from this description, and from the list of the specimens which he refers to as belonging to this order, that the title *Graptolithus* was originally proposed by Linnæus for those well-known markings—dendritic incrustations and the like—which frequently occur in rocks and which simulate fossils, but which had, even previous to his time, been generally acknowledged not to be fossils in the true sense of the word. Indeed, in the twelfth edition of his 'Systema Naturæ,' published in 1767, he asserts definitely, "A Fossil, properly speaking, is not a Graptolite."

1751.
Linnæus,
'Skånska Resa.'

Between the appearance of the first and twelfth editions of his 'Systema Naturæ,' Linnæus published, however, his 'Skånska Resa' ('Travels in Scania'). In that work he figured and described certain markings on a slab which are undoubtedly true fossils, and clearly belong to the group of organic remains now known as Graptolites. His description is as follows:—"Fossil or Graptolite, of a strange kind, ... which, in the grey rock with black characters, resembles a line imprinted with markings like those on the edge of a coin, and often passes into a narrower spiral end."

According to Tullberg (*op. cit. supra*), the slab bearing these fossils was obtained from a gravel hill, named Bybjer, near Herrestad. At this locality Tullberg asserts that no Graptolite shales exist *in situ*, but that loose blocks occur in the mass of gravel.

The exact specific identity of the fossils thus referred to by Linnæus in his 'Skånska Resa' became a matter of considerable controversy among palæontologists on both sides of the Atlantic a century later, but the consensus of opinion at the present day is in favour of the view that the fragments figured by him are true organic remains, and represent two distinct Graptolite species; one being the

species now known as *Climacograptus scalaris* (Linnæus), and the other *Monograptus triangulatus* (Harkness), both of which species are, according to Tullberg, abundant in the blocks of shale occurring at this Scanian locality.

1768. *Linnæus*, 'Systema Naturæ,' edit. 12.

Following the same plan as that originally adopted by him in the first edition of his 'Systema Naturæ,' Linnæus, in his twelfth edition, still employed the term *Graptolithus* for inorganic markings or bodies which *simulate* fossils; and he further divided his order Graptolithus into various species.

Among these species of supposed false fossils, one (given as No. 6) is described as "*Graptolithus* **sagittarius,** with toothed impressions,—'Anonymum. Volkam. Siles.,' 3, p. 332, vol. iv, fig. 6,—found in hard rock, with imbricate impressions, toothed, without a pedicel, regularly arranged, pointed towards the apex." An examination of the figure which is given by Volkmann in his work 'Silesia subterranea,' and which is referred to by Linnæus in the above description, makes it quite clear (as has been pointed out by Tullberg and others) that it represents a *Lepidodendron* or *Sigillaria*, and not a Graptolite at all. Thus the Linnæan name, *Gr. sagittarius*, was employed for a Carboniferous plant, and cannot therefore be retained for a species of Graptolite.

Linnæus' species No. 7 of this twelfth edition of his 'Systema Naturæ,' however, is the same form as that originally described by him as *Graptolithus* in his 'Skånska Resa' of 1751. It is referred to in the text in the following words :—"*Graptolithus* **scalaris,** looking like a line and transverse markings. Found in the common shale of Scania." Linnæus, however, gives no fresh figure. (Compare also 13th edition, Gmelin, 1793.)

1771. *Walch*, 'Naturgeschichte der Versteinerungen zur Erläuterung der Knorr'schen Sammlung von Merkwerdigkeiten der Natur,' suppl. iii.

We find therefore that von Bromell described certain forms now known to be Graptolites as mosses or leaves, while Linnæus described some others in his genus *Graptolithus*, believing them to be "false fossils" simulating true ones. Walch, however, was the first naturalist to recognise the animal nature of the organic remains of the type of the Graptolites of the 'Skånska Resa.' In the supplement to a work of his own on the fossils collected by Knorr, he figures two fossil forms or species which he considers to be minute Cephalopods. One of these is certainly the same form as that subsequently named by Hisinger *Prionotus convolutus*. Walch described this as a "unique species" with a testaceous body like a *Lituites*, and denticulated like the "denticulated Orthoceratites." "Its denticulated border proves that it was chambered, and the teeth mark the extremities of the chamber walls."

The second form figured by Walch is also certainly a Graptolite, but it is difficult to say from the figures to what species the examples given by him should be referred; but it is possible that they belong to the form known at present as

Monograptus priodon (Bronn). Walch refers to them as a new species of "small denticulated Orthoceratites," distinct from *Dentalitæ geniculati.* "The number of chambers appears to be equal in all those of the same length, and those higher up are narrower than the basal ones;" but the siphon, he writes, has not yet been found. Both forms figured by Walch probably come from the same locality, near Stargard, Mecklenburg, from the grey limestone of the Northern Drift. Walch does not name either of his species.

1821. *Wahlenberg,* "Petrificata Telluris Suecanæ," 'Nova Acta Reg. Soc. Scientarum Upsal.'

We find no further mention of Graptolites for the next half-century. But in the year 1821 Wahlenberg recognised the fact that at least one of the forms classed by Linnæus as *Graptolithus* (namely, *G. scalaris*) was a true fossil. But he agrees with Linnæus that none of the other forms (with the exception of *G. sagittarius*) embraced by him in his group *Graptolithus* (or bodies which "simulate fossils") are fossils in the true sense of the word.

Nevertheless, while agreeing with Linnæus in this general opinion, Wahlenberg boldly employed the term *Graptolithus* for the true fossils originally figured by Linnæus as *Graptolithus* in the 'Skånska Resa,' and established these as the original types of the palæontological genus *Graptolithus* or Graptolites in general. In this he has been followed by all subsequent palæontologists, and the term *Graptolites* has been consistently used ever since for all those fossils which are presumably identical with or allied to Linnæus' *Graptolithus scalaris.*

Wahlenberg had the same idea of the nature of the Graptolites as Walch had previously held, and believed them to be true Orthoceratites. He noticed their frequent association with undoubted Orthoceratites in the upper shales of Vestrogothia, and believed that it was possible to trace all the intermediate stages between the large calcareous forms of *Orthoceras*, and the very small membranous and "apparently translucent varieties" which Linnæus had described as *Graptolithus scalaris.* He gives a description of what appears to be Linnæus' *G. scalaris* under the name *Orthoceratites tenuis* in the following terms:—"It has a maximum breadth of barely a line, a length of one inch, and a linear shape. Its joints here and there have been separated from each other alternately, and have been turned over so that they have imprinted in the shale circles smaller than mustard seed. Longitudinal types, instead of a siphon, show a definite medullary nerve (thread), to the sides of which dissepiments are attached, often opposite each other, as in their natural position, but sometimes alternating. This (alternation), however, might have been brought about by disturbance or by obliquity." These small fossils (the Graptolites), he writes, occur frequently alone, only rarely mixed with the larger forms (of Orthoceratites). He concludes from this that they "lived on as such through the period of the upper shales, after the extinction of all the large Orthoceratites."

Wahlenberg describes the occurrence of similar Graptolites also in Dalecarlia (at Osmundsberg and Furudal), and notices carefully the various conditions of preservation in which they are found. "In the shale of Scania, which always has a black colour, the Graptolites occur as impressions with a certain peculiar lustre, or when pyrites is present are rusty, and at the same time they are occasionally found as solid bodies filled up with pyrites." These, he contends, "show clearly the nature of Orthoceratites."

In addition to Linnæus' *G. scalaris*, Wahlenberg also notices the occurrence of certain one-sided forms which he erroneously refers to Linnæus' *G. sagittarius*. According to the Swedish geologists, the form identified by Wahlenberg with *G. sagittarius* is probably identical with the species subsequently named *Monograptus leptotheca* by Lapworth. At any rate, it is quite clear that it is not the same as Linnæus' *G. sagittarius* (see *ante*). He holds that there is but little doubt that these one-sided forms have their origin from the same minute Orthoceratites by a peculiar kind of decomposition. "Some of these Orthoceratites, which had a siphon or a lateral nerve, seem to have curved themselves after the destruction of the opposite wall, and so to have produced lines on one side like the points of an arrow." He considers that these arrow-like structures, which are curved, have arisen from the "interlocular dissepiments."

The result of Wahlenberg's work was to call general attention to these fossils, and the observers who succeeded him found no difficulty in recognising the organic remains thus fixed as "Graptolites," and they employed the term strictly in Wahlenberg's sense.

1822. *Von Schlotheim*, 'Nachträge zur Petrefaktenkunde,' pt. ii.

The views of Walch and Wahlenberg, with respect to the Cephalopodous nature of the Graptolites (as thus restricted by Wahlenberg), were adopted by von Schlotheim, who, in 1822, described and figured a Graptolite under the name *Orthoceratites* **serratus**. It is impossible to identify this species with certainty from Schlotheim's figure, but the "haarförmige Nervenröhre," which he notices running down the back of the fossil, is almost certainly the structure now known as the virgula. This form was obtained from the shales of Andrarum. According to von Schlotheim, his species is the same as that described by Schröter in his 'Einleitung,' Th. iv, but we have not been able to gain access to Schröter's paper.

1828. *Brongniart*, 'Histoire des Végétaux Fossiles.'

Von Bromell's primitive idea of the vegetable origin of these curious fossils, however, was not relinquished by all palæontologists, and in 1828 Brongniart described and figured two new species of Graptolites from the limestone of Pt. Levis, under the names of *Fucoides* **serra** and *F.* **dentatus**. The former is the species of *Tetragraptus* which was subsequently described by Hall as *T. bryonoides* ('Graptolites of the Quebec Group,' 1865), and the latter is a *Diplograptus* (*D. dentatus*).

1829. *Holl, Fr.,* 'Handbuch der Petrefakten,' vol. ii.

In 1829 Holl gave a short description of Schlotheim's *Orthoceratites serratus* in his own text-book, but added nothing to our knowledge of the structure of Graptolites.

1830-35. *Nilsson.*

According to Dr. Beck and Prof. Eichwald, Prof. Nilsson of Lund published about this time (in the 'Transactions of the Physiographic Society' in Lund) some notes on the nature of Graptolites; but according to Tullberg (*loc. cit. supra*) there is nothing written by Nilsson to that effect in the publications of the society. It seems fairly certain, however, that Nilsson (either in a letter or in a manuscript) distinctly formulated the opinion that Graptolites are polyparies belonging to the "Polypi ceratoporæ," or horny Polyps.

Nilsson proposed to change Linnæus' name of *Graptolithus* to *Priodon*. But this name had already been employed by Cuvier for a genus of fish, and Nilsson therefore, in a letter to Hisinger, dated December 27th, 1835, writes, "I have named the genus of *Graptolites* **Prionotus** (like a saw), both in my annotations (where a sketch of a monograph on this genus is to be found) and in letters to several foreigners. I regret that I gave the name wrongly through a slip of memory once when visiting you in Stockholm." (He probably here refers to the generic name originally proposed by him, namely, *Priodon*.) "The name *Prionotus* I consider characteristic, and I therefore intend to retain it." This name, however, was also preoccupied, and it has therefore subsequently fallen into disuse among graptolithologists.

1835. *Bronn,* 'Lethæa Geognostica,' vol. i.

The confusion in the nomenclature of the Graptolites was not diminished by Bronn, who in 1835, in his 'Lethæa Geognostica,' described a new species, and suggested a fresh generic name, **Lomatoceras**, instead of Nilsson's already preoccupied name of *Priodon*. This choice was as unfortunate as that of Nilsson, for the name was already in use for a special genus of insects. The species figured and named by Bronn is his well-known *Monograptus* **priodon**. Bronn figured this form very accurately. He grouped *Lomatoceras* as one of the genera of the Polyparia; but in his description he speaks of the siphon and inner chambers as if the fossil were a Cephalopod.

1837-40. *Hisinger,* 'Lethæa Suecica, seu Petrificata Sueciæ.'

The Swedish naturalist Hisinger gave special attention to the Graptolites of his native country, and described and figured many new forms. He was originally ('Anteckningar i Physik och Geognosi,' p. 168) of the same opinion as Wahlenberg with regard to the zoological place of the Graptolites; but in 1837 (in his 'Lethæa Suecica, Supplementum') he relinquished his earlier view of their alliance with the Cephalopoda, and agreed with Nilsson in referring the Graptolites to the "Polypi ceratoporæ." In this work he described and figured Linnæus' *Graptolithus scalaris*, and the form identified by Wahlenberg with Linnæus'

Gr. sagittarius, together with three new species of his own, namely, *P.* **pristis**, *P.* **folium**, and *P.* **convolutus**. Three years later he described and figured in his 'Supplementum secundum' three additional forms, namely, *Pr.* **geminus**, *Pr.* **teretiusculus**, and a net-like form. This last was a *Dictyonema*, although he regarded it as the impression of a monocotyledonous plant. All Hisinger's species were classed by him under Nilsson's generic name of *Prionotus*.

1839. *Murchison*, 'The Silurian System.'

In 1839, Murchison, in his 'Silurian System,' quotes the views of Dr. Beck, the Danish naturalist, as to the probable nature of the Graptolites. He writes, "Very different opinions have been entertained as to the place which the Graptolites hold in the series of living beings, but that of Professor Nilsson may come nearest to the truth, who conceives the Graptolite to be a polyparium of the ceratophydian family. Yet I am more inclined to regard them as belonging to the group *Pennatulinæ*, the Linnæan *Virgularia* being the nearest form in the present state to which they may be compared." Dr. Beck refers to the new names of *Priodon* and *Lomatoceras*, suggested by Nilsson and Bronn respectively, but considers both to be unnecessary.

Three species of Graptolites are figured in Murchison's 'Silurian System.' The descriptions of two of these are by Beck, namely, those of *Graptolithus* **ludensis** and *G.* **Murchisoni**. The name *G. Murchisoni* was given by Beck, but the name *G. ludensis* was substituted by Murchison for a form previously recognised by himself, which had been named by Beck in his MSS. *Graptolithus* **virgulatus**. One of the forms figured as *G. ludensis* is identical with Bronn's *Monograptus priodon;* the other is rather of the type of *M. colonus* of Barrande. *G. Murchisoni* is an example of *Didymograptus*. The third species, *G.* **foliaceus**, is a *Diplograptus*, and is described by Murchison himself.

Murchison emphasises throughout his work the fact that the range of the Graptolites is exclusively Silurian, and he records them as high up in the series as the lower Ludlow shales.

1840. *Quenstedt*, "Ueber die vorzüglichsten Kennzeichen der Nautileen" 'Neues Jahrb. f. Min.,'

Quenstedt, in a short paper in the 'Neues Jahrbuch' in 1840, notices the structure of certain Graptolites. He adopts the views of the older palæontologists that they belong to the family of the Cephalopoda, and he states that he "does not see why Nilsson should place them among the sea-pens." But he evidently does not consider that the question of their affinities is definitely settled, for he says elsewhere, "A close examination of well-preserved specimens might, however, perhaps strengthen the view that they all belong to the class of the Foraminifera, and not either to the Cephalopoda or to the corals."

As regards the structure of the Graptolites, he notes that he has observed distinct transverse partition walls, as in the Cephalopoda, but no last chamber. He recognises also a siphon running down the back of the shell. He considers

with Wahlenberg that the toothed appearance of one of the margins is not original, but a result of the mode of preservation. He describes and figures two species of Graptolites, *G. scalaris*, Linn., and *G. tenuis*, Wahl., and redescribes (without figuring) the *G. serratus* of Schlotheim. Quenstedt's drawings are figures of fragmentary forms, and represent two unidentifiable forms of *Monograptus*.

1840. *Eichwald*, "Ueber das silurische Schichtensystem in Estland," 'Zeitschr. f. Natur. u. Heilk. d. mediz. Akad. zu St. Petersburg,' Hfte. 1 & 2.

During the same year Eichwald ("Ueber das silurische Schichtensystem in Estland") described a new species of Graptolite from the Silurian formation under the name of *Lomatoceras* **distichum**. This he considers to be quite distinct from any previously noted species of this genus, on account of its being denticulated on both sides. He dismisses the matter of the affinities of the group in a single sentence: "The Lomatocerases or Graptolites are absolutely problematical bodies, which can scarcely belong to the Cephalopoda; one might rather class them in a family among the Zoophytes."

1842. *Geinitz*, "Ueber Graptoliten," 'Neues Jahrbuch.'

Two years later (1842) appeared Geinitz's first paper on the Graptolites, entitled "Ueber Graptoliten." In this paper he gives a diagnosis of the genus *Graptolithus*, and includes under it forms both with two rows and one row of cells. He considers that all Graptolites actually consisted of two rows of cells spread out in one plane; the single-rowed appearance of some being due to the fact that the two halves have got applied the one on the other. He does not think, however, that the "animal could fold itself up ('clap itself together') at will, owing to its firm though thin shell." He describes and figures five species of Graptolites, viz. *Graptolithus foliaceus* (which may be a *Retiolites*), *Gr. priodon*, *Gr. serratus*, *Gr. scalaris* (which is a *Monograptus* of the type of *M. Hisingeri*), and a new form, *Gr.* **spiralis**. Some of those which he grouped under a single name, especially his *Gr. spiralis*, included more than one species as at present understood. The general structure of the fossils, however, is well represented in his figures. Geinitz notices in this paper the fact that the cells become larger and more closely set as the polypary grows older.

Geinitz also discusses the affinities of the Graptolites. He suggests that they bear great resemblance to the Chætopods, but he does not definitely class them with that group, and agrees with Walch, Wahlenberg, and earlier observers in placing them with the Cephalopods.

1842. *D'Orbigny*, 'Voyage dans l'Amérique méridionale,' t. iii, pt. iv, "Paléontologie."

In the same year d'Orbigny (in his 'Voyage dans l'Amérique méridionale') figured fragments of a single branch only of a new species from Bolivia, which he named *Gr. dentatus*. According to him it is a two-branched form identical with *Gr. foliaceus* and *Gr. Murchisoni*. It is difficult to understand, therefore, why he suggested a new specific name,

especially as he considers that the specific names of Graptolites have been too much multiplied, varieties resulting from the effects of "alteration and deformity" being described as different species.

1842. *Eichwald,* 'Die Urwelt Russlands.'

Eichwald, in 1842 ('Die Urwelt Russlands'), described and figured under the new name of *Gorgonia* **flabelliformis** the same form as had been previously described as a moss by von Bromell, and as a monocotyledonous plant by Hisinger. Eichwald believed, however, that it was the impression of a coral resembling *Fenestella.*

1842. *Vanuxem,* 'Geological Report of the 3rd District of New York.'

In the same year Vanuxem noticed the occurrence of *Gr. dentatus* and *Gr. scalaris* in the Utica slates of America, and figured an example of the former species. He distinctly advocates the vegetable nature of the Graptolites: "The ramose nature of two of the species shows that their origin is vegetable, not animal as conjectured by some naturalists. Their chemical composition confirms their vegetable nature; no animal ever existed whose material was almost entirely carbon, as is the case with these fossils."

1843. *Portlock,* 'Report on the Geology of Londonderry and of Parts of Tyrone.'

The appearance of Portlock's 'Report on the Geology of Londonderry and of Parts of Tyrone,' which was published in 1843, marks a distinct epoch in the history of our knowledge of the Graptolites. His work, however, was rather prophetic than conclusive, for his own personal researches on the various species of Graptolites, even when reinforced by the work done by previous observers, were wanting in that knowledge of the details of structure which Barrande subsequently obtained. But Portlock's acumen was so great that he deserves a place second only to Barrande, and he may be regarded as the precursor of the new era which Barrande subsequently founded.

Portlock describes and figures nine species of Graptolites: six of these had been named by previous authors, namely, *Graptolithus convolutus, Gr. foliaceus, Gr. folium, Gr. pristis, Gr. sagittarius, Gr. scalaris?* whilst three—*Gr.* **Sedgwickii,** *Gr.* **distans,** and *Gr.* **tenuis**—were new forms named by himself.

Portlock strongly advocated and endeavoured to demonstrate the polyp-like character of the Graptolites, and he controverted the view that they were allied to the Orthoceratites. The presence of septa may, he considers, merely indicate the connection of the polyp cells with an internal axis. The double and single Graptolites, according to him, seem more analogous to Sertularia and Plumularia, but differ in having neither branches nor pinnæ. The cell-like structure seen in a scalariform view is analogous to that seen in the Cellaria. Portlock considers that it is probable that there are several Graptolite genera belonging to even more than one order. He does not, however, suggest new names for these genera, and the species described are all grouped by him under the single old generic name *Graptolithus* of Linnæus.

1843.
Hall,
'Geological Report of the 4th District of New York.'

During the same year Hall, while describing a new species—*Gr.* **clintonensis**—notes the fact that the shales in which Graptolites occur are black, as if from the carbonaceous matter derived from the fossils. This, he points out, would seem to argue against placing these bodies among the calcareous Polyparia, but he does not suggest their alliance with any other group of the animal kingdom.

1844.
Emmons,
'The Taconic System.'

In his 'Taconic System' Emmons gives figures of certain fossils which he names *Fucoides* **simplex** from the roofing slate of Hoosic, New York. These fossils, he says, "have much the appearance of the Graptolites of the Utica slates, but which I am now satisfied are marine vegetables." There can be but little doubt, however, that Emmons' fossils are really Graptolites of the type of *Diplograptus foliaceus* of Murchison; but, owing to the cleavage that the containing rock has undergone, the fossils present very different appearances according to their position on the slab.

1843–4.
Mather,
'Geological Report of the 1st and 2nd Districts of New York,' pt. i.

The general view held by Americans about this time as to the vegetable nature of the Graptolites was also endorsed by Mather in his 'Geological Report' in 1843. Mather mentions that there are at least five species of these plants (Graptolites) in the Utica slates, and that they also occur in the Hudson River group, but he does not describe them. He copies Vanuxem's figures of *Gr. dentatus.*

1844.
Owen,
"Review of the New York Geological Reports," 'Amer. Journal,' vol. xlvii.

Owen, however, in a review of Vanuxem's work (*op. cit. supra*, 1842), points out the differences between the views of Vanuxem and those of the European geologists as to the zoological affinities of the Graptolites, and seems himself to incline to those of the latter. He suggests that the carbonaceous matter almost invariably found in connection with the Graptolites "may have resulted from the peculiar conditions and circumstances attending their deposition;" and he asks, "might not, by the action of some chemical affinity, the less stable elements of the Polyparia have been removed and the carbon alone left?"

1845.
Boubée,
'Bull. de la Soc. Géol. de France,' ser. 2, t. ii.

In 1845 Boubée recorded in his paper "Sur les Graptolites des Pyrénées" the occurrence of *Graptolithus sagittarius* in the Silurian beds of the Pyrenees.

1845.
Murchison, de Verneuil, and Keyserling.

Murchison, de Verneuil, and Keyserling, in their 'Geology of Russia and the Ural Mountains' (vol. ii), note the occurrence of *Graptolithus sagittarius* and *Gr. distichus* in the Silurian beds of Russia.

In the year 1846 Geinitz, in a second paper on Graptolites, suggested the first

1846. *Geinitz*, 'Grundriss der Versteinerungskunde.'

subdivision of the forms then included under the genus *Graptolithus*. He divides them into (*a*) straight, and (*b*) spirally curved forms. In the first group (*a*) he places (1) *Gr. foliaceus*, (2) *Gr. pristis*, (3) *Gr. folium*, (4) *Gr. dentatus*, (5) *Gr. priodon*, (6) *Gr. ludensis* (with its variety *Gr. virgulatus*), (7) *Gr. teretiusculus* (this he regards as synonymous with *Gr. priodon* and *Gr. sagittarius*), (8) *Gr. sagittarius* (which he believes to be identical with *Gr. scalaris*), and (9) *Gr. serratus*. He refers to the two branched forms, *Gr. geminus* and *Gr. Murchisoni*, and suggests with considerable hesitation that they may be identical with *Gr. sagittarius* and *Gr. priodon* respectively. In the second group (*b*) he places only one species, *Gr. convolutus*. He figures a few of these species, but some of his figures are merely copies of those of previous authors. His figure of *Gr. foliaceus* clearly represents an example of *Retiolites Geinitzianus*, and the network is well shown. He retains unmodified his previous views as to the structure and affinities of the Graptolites (*op. cit. ante*, 1842).

1847. *Hall*, "Graptolites of the Inferior Strata of the New York System," 'Palæontology of New York,' vol. i.

In 1847 Hall described in his "Graptolites of the Inferior Strata of the New York System" a number of forms of Graptolites from the Utica slate and the beds of the Hudson River group. The species described and figured include five forms identified by him with forms described or noticed by previous authors, and eight additional species for which new names are proposed. It is very doubtful if any of the forms referred by Hall to species previously described are identical with those species. Thus his (1) *Gr. pristis* (His.) is not Hisinger's form of that name; (2) *Gr. scalaris*, Linn., is mainly *Climacograptus bicornis*, Hall; (3) *Gr. secalinus*, Eaton, is an ally of *Diplograptus foliaceus*, Murch., deformed by cleavage; (4) *Gr. sagittarius* (His.) is almost certainly an example of *Didymograptus*, as is also (5) *Gr. tenuis* (Portlock). The new species described and named by Hall include (6) *Gr.* **sextans,** (7) *Gr.* **furcatus,** (8) *Gr.* **ramosus,** (9) *Gr.* **serratulus,** (10) *Gr.* **bicornis,** (11) *Gr.* **mucronatus**, (12) *Gr.* **gracilis**, and (13) *Gr.* **lævis**. This last is not a Graptolite, but an alga or a worm track. All the figures are good, and nearly all the species are recognisable.

Hall at that time grouped all these Graptolites under the single title *Graptolithus*, which was the only genus then recognised, but several of them have subsequently been made the types of distinct genera. Thus the forms there described as *Gr. bicornis*, *Gr. ramosus*, *Gr. sextans*, and *Gr. gracilis* became the accepted types of the genera *Climacograptus*, *Dicranograptus*, *Dicellograptus*, and *Cœnograptus* respectively.

Hall says little or nothing of the structure of the Graptolites, merely remarking that they had a "semi-calcareous body with a corticiform covering." As regards their zoological affinities, he considers that they have a close analogy with *Virgularia*.

1847. *Nimmo,* 'Calcutta Journal of Natural History,' vol vii.

Nimmo, in the year 1847, expressed his belief that *Gr. foliaceus* is nothing more or less than the "serrated tail spines of the *Raja pastinaca*," or an allied species. Such a theory, founded as it was upon the most imperfect knowledge of the structure of a Graptolite, hardly merits serious consideration.

1848. *Phillips and Salter,* 'Memoir of the Geological Survey,' vol. ii.

In 1848 Phillips and Salter recorded *Graptolithus pristis* (?), *Gr. ludensis*, and *Gr. Murchisoni* (?) from the Llandeilo rocks of Western England and South Wales; and in accordance with the general opinion of the palæontologists of that day, the Graptolites are placed by these authors among the organisms then classed as Polyparia.

1848. *Sedgwick and M'Coy,* "On the Organic Remains found in the Skiddaw Slates," 'Quart. Journ. Geol. Soc.,' vol. iv.

Sedgwick, in a paper on the 'Organic Remains of the Skiddaw Slates,' published the same year, records *Graptolithus sagittarius* from the Skiddaw slates. In an appendix to this paper M'Coy describes and figures a new species, *Gr.* **latus.** It is clear from the figured example that *Gr. latus* was in all likelihood founded on a branch of a Dichograptid, possibly the *Didymograptus hirundo* of Salter.

1849. *Bronn,* 'Geschichte der Natur,' vol. iii, part 2.

In 1849, Bronn gave a list of the Graptolites known up to that time. These include *Graptolithus convolutus*, *Gr. sagittarius*, *Gr. priodon*, *Gr. ludensis*, *Gr. Sedgwickii*, *Gr. distans*, *Gr. tenuis*, *Gr. dentatus*, *Gr. scalaris*, *Gr. distichus*, *Gr. pristis*, *Gr. foliaceus*, *Gr. folium*, *Gr. teretiusculus*, *Gr. Murchisoni*, *Gr. geminus*. As regards the position that the Graptolites occupy in the animal kingdom, he classifies the Graptolithina as one of the sub-families or groups of the Anthozoa.

1849. *Salter,* 'Quart. Journ. Geol. Soc.,' vol. v.

Salter, in his "Note on the Fossils from the Limestone on the Stinchar River, and from the Slates of Loch Ryan," gives figures of seven species of Graptolite: *Gr. folium*, *Gr. pristis* (which appears to resemble *Gr. mucronatus*), *Gr. pristis*, var. *foliaceus*, *Gr. ramosus*, *Gr. tenuis*, *Gr. sextans*, and a new form which he names *Gr.* **tænia.** This last it is impossible to identify with certainty.

One of the figures given by Salter represents eighteen specimens of *Gr. sextans* (*Dicellograptus*) apparently suspended on a branch of this so-called *Gr. tænia*. This figure is of special interest from the modern point of view, as bearing on the mode of life of the Graptolites; but Salter himself does not draw any conclusions from the curious association.

1849. *Sharpe,* 'Quart. Journ. Geol. Soc.,' vol. v.

In 1849, Sharpe, in his paper on the "Geology of the Neighbourhood of Oporto," notified the occurrence of *Graptolithus Murchisoni?* in association with Trilobites of Lower Silurian age.

1849.
Hall,
"On Graptolites: their Duration in Geological Periods and their Value in the Identification of Strata," 'Proc. Amer. Ass. for the Advancement of Science.'

In the same year Hall discussed the geological range of the Graptolites in America in some detail. He observes that they are peculiarly typical of the Lower Silurian; "few are known in a higher position, being less widely distributed and very limited in geological range." That is to say, there are fifteen species found in the Lower Silurian, and three in the Upper Silurian. Of these three species, two—*Gr. clintonensis* and *Gr. venosus*—are peculiar to America, and occur towards the base of the upper division in the Clinton group, and the third—*Gr. ludensis*—at a slightly higher horizon.

He describes the new form *Gr.* **venosus** (which is now known to be a species of Barrande's genus *Retiolites*) as "broad, with a central capillary axis and serratures on both sides." The whole substance is finely veined or reticulated, like the skeleton of a leaf. On account of its peculiar structure he thinks it may "very well form the type of a new genus in the future." Hall does not discuss the affinities of Graptolites fully, but as it is impossible to trace the connection of these fossils with any living forms through the Devonian and Carboniferous rocks, he is "disposed to question their analogy with the Sertularidæ or Pennatulidæ."

1850.
M'Coy,
"On some New Genera and Species of Silurian Radiata in the Collection of the University of Cambridge," 'Ann. Mag. of Nat. Hist.,' ser. 2, vol. vi.

In 1850 M'Coy gave a diagnosis of the family of the Graptolitidæ in the following words:—"Stem simple or branched, thin, usually linear, horny, unrooted; polyp cells divided at bottom by a transverse diaphragm." M'Coy was thus the first palæontologist to draw attention to the "free" nature of the Graptolites, and he points out distinctly that in this particular they differ from the Sertularidæ, "with which, however, they agree in the form of the polypidom and the cells." His view of the presence of a transverse diaphragm at the base of the cells was probably obtained from an examination of Lake District specimens, as markings suggestive of septa were described later by Hopkinson from similar material.

As regards the method of reproduction of the Graptolites, M'Coy acknowledges that no ovarian vesicles have been found so far, but he suggests that the ova were developed in naked sacs attached to the base of the tentacles of the polyps, and hence were not preserved: this position of the reproductive organs would be analogous to that in *Corymorpha*. His views, he is careful to point out, are much the same as those previously published by Nilsson and Portlock.

An important advance as respects the classification of the Graptolites was made by M'Coy in this paper, for he recognises that the structural differences between the uniserial and biserial forms ought to be regarded as of generic value, and suggests that the name *Graptolites* should be restricted to the former

(the single-sided forms), and he proposes the new name **Diplograpsis** for those Graptolites which have denticles on both sides. This suggested nomenclature was soon generally adopted, but there has been considerable discussion among subsequent writers as to whether the original Graptolite described by Linnæus as *G. scalaris* was not in reality a biserial form, and that consequently the generic name *Graptolites* ought rather to be used for biserial than for uniserial forms.

M'Coy gives figures of three new species of Graptolites, namely, *Gr.* **lobiferus**, *Gr.* **millepeda**, and *Diplograpsis* **rectangularis.** He does not, however, give any description of these forms.

1850.
Nicol,
"Observation on the Silurian Strata of the S.E. of Scotland," 'Quart. Journ. Geol. Soc.,' vol. vi.

Nicol, in a paper which is mainly stratigraphical, described and figured a new species of *Monograptus*, *Graptolites* **griestonensis.** Descriptions are also given of *Graptolites convolutus* (which he considers to be identical with *Gr. spiralis* and *Gr. ludensis*), and a "foliaceous species" which, "if a true Graptolite, seems undoubtedly a new species." To this he gives the name **Gr. laxus**. He points out "that it so closely resembles some plants of the moss tribe (*Hypnum*) as to render its real character doubtful."

Nicol gives a brief review of the opinions previously held by palæontologists as to the true character of Graptolites, and asserts that while the general opinion is in favour of their being Polyparia, he finds that some are carbonaceous, some horny; and he throws out the suggestion that these remains may have belonged to animals of more than one class, and that "some of them may have been internal organs, rather than the external axis of a variety of polypifer."

1850.
Naumann,
'Lehrbuch der Geognosie,' vol. i.

In 1850 Naumann gave four woodcuts of Graptolites, and also figured seven species in an illustrative lithographic plate. All these, however, are bad copies of figures taken either from Murchison's 'Silurian System' (*Gr. ludensis*, *Gr. Murchisoni*) or from Geinitz's illustrations in the 'Neues Jahrbuch' for 1842 (*Gr. folium*, *Gr. convolutus*, *Gr. sagittarius*, *Gr. priodon*, and *Gr. scalaris*), and they give no new information.

1850.
Richter,
"Aus der Thüringischen Grauwacke," 'Zeitsch. d. Deut. geol. Gesell.,' Bd. ii.

Richter's first contribution to the study of the Graptolites was published in 1850, and dealt mainly with questions of classification and structure. His classification is very similar to that suggested by Geinitz in 1846. He divides Graptolites into two groups: (I) curved (or single-toothed), and (II) straight (or double-toothed); and suggests a possible third class, or "closed." Under the first group (curved forms) he includes two species: (1) *Graptolithus sagittarius*, of which he gives seven figures; and (2) *Graptolithus*, species unnamed. Three of his figures of *Gr. sagittarius* are probably drawings of examples of *Monograptus cyphus*, while three others are clearly of forms

belonging to the Diplograptids. The species which he refers to as *Graptolithus*, sp., seems to be Barrande's *Rastrites peregrinus*.

In his second group (*straight* or double-toothed Graptolites) Richter includes four species: (3) *Gr. folium;* (4) *Graptolithus*, sp., for which he suggests the new name *Gr. mucronatus* (a name already preoccupied); (5) *Gr. priodon*, of which he gives no figure, and which he thinks might belong to a third group—the *closed* Graptolites; and (6) *G. scalaris*, under which he apparently includes the two forms usually known in recent years as *Climacograptus normalis* and *C. rectangularis*.

The figures given by Richter are for the most part good, and show well the typical graptolitic structure. He notices such details of structure as (1) the alternating arrangement of the cells in double Graptolites, a character which he considers invariable; (2) the thickening of the wall at the aperture; and (3) the prolongation of the virgula (or the "siphon," as he calls it) in a proximal direction. This last phenomenon he holds may be explained either by the fact that the cells have dropped off, or that they were very small during life.

Richter notes that the species of Graptolites described were all obtained by him from the Silurian formation of the Thüringer Wald, in the neighbourhood of Saalfeld, but gives nothing as to their further range or geographical distribution.

CHAPTER II.

Second Period, 1850 to 1865.

1850. *Barrande*, 'Graptolites de Bohême.'

In the year 1850 appeared Barrande's epoch-making work on the 'Graptolites de Bohême.' This added so largely to our previous knowledge of the Graptolites, and was marked throughout by such an admirable method of treatment, simplicity and clearness in the presentation of the facts, and brilliance of inference and generalisation, that it gave an impetus to their study, the importance of which can hardly be over-estimated. The work is one of much detail, and it will be best to discuss it in the order of arrangement that Barrande himself adopts.

General Sections.

1. *Nature of the Graptolites.*—Barrande considered that the evidence he had himself accumulated as to the nature of the Graptolites was strongly opposed to the view held by the majority of previous observers, namely, that the Graptolites were

allied to the Cephalopods. He cites the following arguments in support of his opinion:

(1) In some species there is a single row of cells, in others a double series.

(2) No Graptolite has a large terminal chamber like that of the Cephalopoda.

(3) Each Graptolite cell has its independent opening.

(4) Certain species of Graptolites were attached to the sea floor, as appears to be evident from Hall's figures.

Barrande agrees with Nilsson that the Graptolites must be regarded as belonging to the class of the Polyparia, but that not enough is known to determine exactly to what family they belong. He is inclined, however, to agree with Dr. Beck that they should be grouped with the Pennatulinæ, near the genus *Virgularia*.

2. *General Form.*—As regards the general shape of the Graptolites, Barrande recognises only two structural forms, viz. (1) the single-celled species, (2) the double-celled species; the former being straight or curved either spirally or conically, and the latter being always straight.

3. *Solid Axis or Virgula.*—Barrande, although not the first to observe the important body known as the *solid axis*, was the first to discern its invariable presence in Graptolites, to describe its constitution, and to give it its name. He writes, "Graptolites are always provided with a solid axis. This axis is cylindrical and fibrous, and may be prolonged beyond the cellular part in certain monoprionidian forms (*Gr. colonus*). In the double-celled forms also the axis is similarly prolonged, and is probably double, the two portions possibly forming a much flattened tube between the two series of cells (*Gr. palmeus*)." He considers it possible, judging from the upper part of the axis in *Gr. palmeus*, that each of these portions may consist in its turn of two layers, which have become separated by decomposition. In *Gladiolites*, however, Barrande notes that he could discern no true solid axis.

4. *Common Canal.*—Barrande first applied the name of "common canal" to that tube-like portion of a Graptolite which lies between the axis and the individual cells. In the double Graptolites there appear to be two common canals, quite independent of one another, and Barrande gives drawings of cross-sections of *Gr. priodon* and *Gr. palmeus* to illustrate the simple and double nature of this body. In *Gladiolites* there is only one median canal. As regards the function of this canal, Barrande is quite definite. He asserts that "this space enclosed the body of the polyp, and from it arose the individual germs living in the cells." "It served as a conveyance of common nutrition, and also as transport for the new germs."

5. *Cellules.*—The individual cells, or cellules, are in intimate connection with the common canal, but each germ is individualised, and constructs a cell with solid walls for itself. These cellules are inclined to the axis at various angles, are

sometimes in contact for their whole length (*Gr. colonus*) or for part of their length (*Gr. priodon*), or they are quite free as in *Rastrites*.

In form, each of the cellules may be compared to "a small sac," the length of which is always greater than the width, and is either rectangular or circular in section. Sometimes they narrow towards their orifices, or they curve over in the form of a hook (*Gr. priodon*). Barrande considers that there is no doubt that the wall between two contiguous cellules is double, and he represents this in his figures of *Gr. priodon*.

Each cellule, according to Barrande, has two orifices:

(1) *The internal orifice*, communicating with the common canal, and generally subrectangular or round in shape;

(2) *The external orifice*, which presents many variations in form.

He discusses the various forms of cell apertures in considerable detail, from the simple straight apertures of *Gr. bohemicus*, which open upwards, through the oblique and spinose ones of *Gr. testis*, etc., to the curved ones of *Gr. priodon*, which open downwards. The apertures of several species are provided with spines, and when two spines are present these are arranged either above and below the aperture (*Gr. chimæra*), or symmetrically on the lateral parts of the border (*Gr. testis*). Barrande records all these spines or "ornaments" as "simple appendages of the test."

6. *Nature and Ornaments of the Test.*—The solid test of the Graptolites is about ·1 mm. in thickness, and of a horny character. Barrande believes that it contains little, if any, carbonate of lime, and is inclined to think that it is largely carbonaceous; and he points out that the black colour of the shales in which Graptolites occur seems to confirm this opinion.

As regards the markings and superficial ornamentation of the test, he observes oblique striations on some of the cells, but he does not appear to have realised their vital importance as "growth-lines." Except in *Gladiolites*, the Graptolite test is smooth and continuous. With respect to the genus *Gladiolites*, which he was the first to distinguish, Barrande recognises and describes with great accuracy the peculiar network of threads forming the test, and is of the opinion that the meshes were either open, or else closed by "a membrane chemically different from that of which the network is composed."

7. *State of Preservation.*—Barrande points out that in Bohemia the Graptolites are usually preserved as impressions, but occasionally (in the limestones) they occur in relief with the test preserved, while in certain of the higher beds internal casts alone are found.

The accuracy of the observations of Barrande, the breadth and lucidity of his conclusions and descriptions, and the beauty of his illustrations, make his work not only a classic, but also most valuable for reference even at the present day. But Barrande's work, important as it was, was only a stage in the progress of grapto-

litic research, and in the subjects treated of in the subsequent sections of his memoir, later observers have made considerable advances upon his original views.

8. *Mode of Growth of the Graptolites.*—Barrande's view of the method of growth of the Graptolites is very different from that accepted at the present day. Observing that the polypary increased in width in one (the distal) direction and decreased in the other (the proximal), he considered that the proximal part with the smaller cells was the younger, or, as he termed it, the *growing portion*, while the widest part (distal) was the *adult portion*. He concluded that "the growth of the polypary took place, therefore, by the successive appearance of new 'germs' at the narrow end." These germs are at first very distant (as in *Gr. proteus*), while in the adult portion they are in contact. He was therefore of the opinion that the "elongation of the body of the polypary must have preceded the production of any new germ. Thus this body would seem to have served as a canal of propagation." Barrande, however, points out that there are at least two foreign species in which such a mode of growth is impossible, viz. *Gr. Murchisoni* and *Gr. geminus*. These consist of two branches united by a small terminal "stem." In these forms he seems clearly to have realised that the growth must be in the opposite direction to that advocated by himself for the Bohemian forms.

Again, the fact that many single- and double-celled forms show a naked axis prolonged beyond the so-called adult end, Barrande considers may be explained by the "perishing of the older cells, one after the other, as the younger cells are developed." The occasional prolongation of the axis also beyond the narrow end of the polypary can, according to Barrande, only be interpreted by the "accidental decomposition of the young cells after the death of the individual before fossilisation." Another difficulty, presented by the not infrequent decrease of the cells towards the adult end, is also explained by him in the same way. Considering the cautious deductions from facts observed in most of the other parts of this book, it might appear strange at first sight that Barrande should have adopted so definitely this theory as to the method of growth; but it must be remembered that at that time the complex Canadian forms, in which such a mode of growth is demonstrably impossible, had not been described.

9. *Mode of Existence.*—As respects the mode of existence of the Graptolites, Barrande only considers the single question whether the Graptolites were free or fixed; and he agrees with M'Coy that, as far as the evidence of the Bohemian species goes, it is "very probable that they were entirely independent." There is no evidence of adherence of Graptolites to rocks, as is the case with modern Zoophytes and Molluscs. It would have been impossible for them to be fixed to the ground by the growing portion, on account of its slender and frequently curved character, and there is no evidence whatsoever to suggest that they were fixed by the adult end. With regard to such forms as *Gr. bicornis* and *Gr. Murchisoni*, however, Barrande considers that the invariable presence of a "point" or

"pivot" at one end seems to indicate with fair certainty a fixed mode of life. He therefore concludes that it is probable that "certain Graptolites lived attached, while others floated or swam freely in the Silurian seas."

10. *General Characters of the Family of the Graptolites.*—Barrande points out that since the name *Graptolithus* was founded on such forms as *Gr. sagittarius* and *Gr. scalaris*, it should be maintained for all those species showing some analogy to these; but he suggests that the genus *Graptolithus* should be separated into two sub-genera, viz. **Monoprion,** including those with one row of cells, and **Diprion,** embracing those with two parallel rows.

As regards the curious Y-shaped form figured by Hall as *Gr. ramosus*, Barrande is inclined to regard it as an accidental phenomenon produced by the splitting of a Diprion form. He considers that the name *Graptolithus* should be restricted to those forms having their cells in contact, and he suggests the name of **Rastrites** for those in which the cells are quite distinct from each other. (This last name has become generally adopted, but the titles *Monoprion* and *Diprion* have never come into general use as generic terms.) Another new generic name proposed by Barrande was that of **Gladiolites** for a Diprion form covered with a fine network of threads, "and having no axis." His alternative title for this genus, **Retiolites,** has been more generally adopted.

11. *Distribution and Range of Graptolites in Bohemia.*—Barrande deals next with the distribution of Graptolites, first in Bohemia, and afterwards in other parts of the world. In Bohemia the vast majority of Graptolites occur at the base of the (Upper) Silurian; some occur in the lowest parts of the inferior limestone, Stage E, but they become rarer in the higher beds, and eventually disappear altogether before Stage F. Regarding the lower limits of their range, there is no evidence of their presence in the beds below Stage D, and therefore it is certain that in Bohemia, at any rate, the Graptolites did not make their appearance until after the disappearance of the primordial fauna.

As respects the kind of rock in which Graptolites are found, Barrande calls attention to the fact that they are most abundant in shales, and rare in siliceous rocks; or, as Murchison had previously put it, "the region of Graptolites is a great region of mud."

Barrande notices especially the occurrence of Graptolites in his "colonies" of Stage D, and indeed employs the Graptolites as evidence of his famous "Theory of Colonies." The existence in the colonies of the same species as are found in the much later Stage E, in association with those characteristic of Stage D, seemed to him to afford a proof that the colonial organisms, including the Graptolites, were "derived from a centre of creation quite different from that where the fauna proper to Stage D took its origin;" and that collectively they were forerunners, so to speak, of a typical Upper Silurian fauna, which did not attain its maximum development until a much later date.

12. *Distribution of Graptolites in Foreign Countries.*—Barrande discusses the question of the general distribution of Graptolites at considerable length, and gives the result of the researches of all previous writers as to their range. Although he collected all the material obtainable on this subject, he contented himself with general remarks as to the range of the Graptolites in time and space. His conclusions may be summed up as follows:—Graptolites belong characteristically to the Silurian system; in England they made their appearance during the period marked by the primordial fauna of Bohemia, reaching their maximum development about the middle of the Silurian period,—that is to say, at the top of the Lower and base of the Upper Silurian; and dying out altogether in the Lower Ludlow beds.

Descriptive Sections.

After giving a historical summary of the literature of the subject, Barrande devoted the rest of his memoir to the description of the various Bohemian genera and species. Both the descriptions and the illustrative figures given by Barrande were far in advance of anything done previously by graptolithologists, and the descriptive letterpress of his work has remained a standard type for diagnosis down to the present day. Several of the beautiful figures upon his illustrative plates, however, are, in accordance with the practice of the time, either generalised from more than one specimen, or somewhat idealised in the matter of detail.

But the state of knowledge of specific characteristics was then naturally inferior to that of the present day, and some of his species included forms now acknowledged to be specifically distinct. Thus under the name *Graptolithus priodon* (Bronn) Barrande not only included Bronn's typical form (Pl. I, figs. 3, 5—9), but at least three other forms also, which are now usually regarded as belonging to distinct species, viz. *Cyrtograptus Murchisoni* (Carr.), *Monograptus spiralis*, var. *subconicus* (Tullb.), and *Mono. Jaekeli* (Perner, 'Études sur les Graptolites de Bohème,' part 3). Again, the illustrations of his own species *Gr. colonus* embrace those of three distinct forms, of which the most characteristic (Pl. II, figs. 2 and 3) is now by common consent regarded as that of the type species, while fig. 5 may probably be assigned to the form at present classed as *Mono. dubius* of Suess, and figs. 1 and 4 to *Mono. vomerinus* of Nicholson. Perhaps the most conspicuous case is that of his *Gr. Nilssoni*, which he illustrates by three figures. Thesea re drawn as if the specimens represented occurred together upon one and the same slab of rock, but they are now known to have been obtained from different localities and from different horizons (Perner, *op. cit.*). Fig. 16 is now regarded as the type form of *Gr. Nilssoni;* fig. 17 as a specimen of *Cyrto. Lundgreni;* while fig. 18 belongs to *Cyrto. tubuliferus* of Perner.

The species of Graptolites identified, described, and figured by Barrande include the (1) *Mono. priodon* and (2) *Mono. spiralis* of earlier authors, and the following

forms which were then new to science :—(3) *Gr.* **Nilssoni**; (4) *Gr.* **colonus**; (5) *Gr.* **bohemicus**; (6) *Gr.* **Roemeri**; (7) *Gr.* **turriculatus**; (8) *Gr.* **Becki**; (9) *Gr.* **proteus**; (10) *Gr.* **Halli**; (11) *Gr.* **testis**; (12) *Gr.* **palmeus,** var. **lata** and var. **tenuis**; (13) *Gr.* **ovatus**; (14) *Gr.* **chimæra**; (15) *Rastrites* **fugax**; (16) *R.* **peregrinus**; and (17) *R.* **gemmatus.** Little or no doubt is left as to the specific characteristics of most of these forms, and they are easily recognisable from Barrande's descriptions and figures.

In the description of his (18) *Gr.* **tectus** and (19) *Gr.* **nuntius**, Barrande enters into a lengthy explanation of the various aspects that the cellules may assume according to the direction of compression. Thus he shows that specimens of Graptolites apparently biserial may really be the compressed scalariform views of a uniserial form. Here, however, Barrande's inference, correct as it was respecting Graptolites in general, led him occasionally astray, and he erroneously described a true biserial species, viz. his *Gr. tectus*, as a uniserial form.

Barrande described the structure of his remarkable new genus, *Gladiolites* (or *Retiolites*), and its type species (20) *G.* **Geinitzianus**, with special care and accuracy of detail. The median filiform axis visible in some specimens he holds to be part of the external network, and not to represent a division between the two series of cellules, for it is often discontinuous. As regards the test of *Retiolites*, Barrande considers it is very improbable that it was continuous as in other Graptolites, but the network might, perhaps, have been covered by a thin film.

Barrande's brilliant memoir acted as a great incentive to the study of individual Graptolite species, and since its publication papers on this subject have been numerous. His clear presentation of the different specific criteria trained the eyes of those who immediately followed him, and for the next twenty to twenty-five years research was mainly in the direction of the collection and description of new species; and side by side with this some important additions were made to our knowledge of the structure, mode of life, and zoological position of the Graptolites. The detailed study of their geological distribution was, however, somewhat neglected, and was not taken up until a much later date. This was, no doubt, owing largely to the fact that graptolithologists, fascinated by the brilliance of Barrande as a palæontologist, naturally accepted also his ideas with respect to migration and colonies, unaware that stratigraphy in the Lower Palæozoic rocks had not yet advanced to that degree of detail by means of which it was possible to interpret correctly the complexities of the Bohemian succession.

1850. *Verneuil*, 'Bull. Soc. Géol. de France,' vol. vii.

In 1850 Verneuil noted the occurrence of *Gr. colonus* and *Gr. testis* in the Ampelite schists of Neuvilette (Brittany). These are included in his "second fossiliferous stage." In his "third fossiliferous stage," the representative of the Upper Silurian, he records *Gr. priodon* as being the most common species.

1851.
Suess,
"Ueber Böhmische Graptolithen,"
'Naturwissensch. Abhandl. von Haidinger,'
Bd. iv, Abth. 4.

Immediately after the appearance of Barrande's memoir on the Bohemian Graptolites, Suess published the results of his own researches on this subject. His labours covered much the same ground as those of Barrande; but his paper, though long and detailed, did not materially advance the subject beyond the point to which Barrande's researches and conclusions had already brought it, and the figures upon the plates which illustrate his paper are indifferent. We may here notice those points respecting which Suess added to or differed from the results already arrived at by Barrande.

Mode of Existence.—In dealing with the character of the rock in which the Graptolites occur, Suess points out that the shales are often very carbonaceous, and frequently contain balls of anthraconite, and he suggests that these balls may have been formed by the rolling in the mud of the remains of marine plants. This is interesting in the light of later opinion concerning the mode of life of Graptolites, and the recent view that they were attached to seaweeds.

Classification.—As regards the classification of the Graptolites, that of Suess differs considerably from that proposed by Barrande. He suggests that there are only three genera, viz.—

1. *Retiolites* (in Barrande's sense);

2. *Petalolithus* (including the sub-genus *Diprion* of Barrande and the sub-genus *Diplograpsis* of M'Coy);

3. *Graptolithus* (embracing forms having only one row of cells). This genus is subdivided into three sub-groups, namely, those having—

(*a*) a strong axis bent into a fixed curve in one plane, and their cells always in contact (*Gr. bohemicus*);

(*b*) an axis at the older end bent into a definite conical screw line; at the younger end thread-like; cells in contact when fully developed, not in young stage (*Gr. proteus*);

(*c*) an axis thread-like and curved; cells not in contact (*Rastrites*).

He agrees with Barrande (and is even more consistent in this respect) in considering the narrowest end of the polypary as the younger, and therefore always figures it with that end uppermost.

Structure.—Suess described the genus *Retiolites* and its species *R. Geinitzianus* in much detail, but his explanation of its structure is markedly different from that of Barrande. According to Suess, the axis, which is "sometimes distinct, sometimes almost invisible, not rigid, but flexible," gives rise to alternating secondary branches at regular intervals. As the polypary increases in size, interspaces appear between the secondary branches, and these are formed by the splitting of the branches into two parts from the centre towards the outside. These interspaces are then divided by five or six strong transverse walls at right angles to the secondary

branches. These smaller divisions constitute true "cells." In the widest part of the polypary the branches may split as often as four or five times. Suess admits that it is somewhat difficult to understand how the transverse walls bounding the "cells" were produced. The genus *Retiolites* is distinguished from *Petalolithus* (*Diprion*, Barr) by having its secondary branches united by a distinct cell system instead of by a membranous substance.

Description of Species.—In addition to (1) *Retiolites Geinitzianus* (which Suess regards as synonymous with *Fucoides dentatus*, Brong., *Gr. pristis*, *Gr. scalaris*, *Gr. foliaceus*, *Gr. secalinus*, and other biserial forms) Suess describes and figures a new form under the name (2) *Retiolites* **grandis**. The individuality of this last-named species was not recognised by subsequent writers until a comparatively recent date, when Tullberg made it the type of a new genus, *Stomatograptus*, but his interpretation of its structure is very different from that of Suess. Suess considered it to be distinct from *Ret. Geinitzianus* on account of its larger size, the peculiar form of the outer margin, and the small vertical distance apart of the secondary branches; while Tullberg distinguished it because of its median row of "pores."

Under the description of his new genus **Petalolithus** Suess notes the prolongation of the solid axis at both ends, and agrees with Barrande that it is very probable that the cells have fallen off these naked prolongations. He makes a great point of the alternate or opposite position of the secondary "branches," and thinks it is due to subsequent movement or disturbance. He considers that it is possible to recognise in *Petalolithus* something akin to the cell system in *Retiolites*, and suggests that in *Petalolithus* "those parts which take the place of the cell system in *Retiolites* consisted of a skin-like substance provided with stomata (?)."

He divides the forms assigned to *Petalolithus* into two groups:

(*a*) those in which there is a decrease in width at both ends of the polypary, producing a characteristic oval shape;

(*b*) those in which the distal walls are parallel.

The following species of *Petalolithus* are described and figured:

(3) *P. palmeus;* (4) *P. ovatus;* and a new species, (5) *P.* **parallelo-costatus.**

The structure of the genus *Graptolithus* (*Monoprion*) is next discussed, and he considers that the axis in *Graptolithus* is tube-like, and not solid as Barrande had stated.

In his first group of the genus *Graptolithus* Suess includes forms like *Prionotus geminus*, *Gr. ramosus*, etc. (which, according to him, had the power of branching dichotomously), and describes (6) *Gr. priodon;* (7) *Gr. bohemicus;* (8) *Gr. serratus* (which he believes to be identical with *Gr. dentatus*, *Gr. Roemeri*, and *Gr. latus*); (9) *Gr. testis* (the structure of the aperture and spines of which he describes in great detail); (10) *Gr. lævis* (Hall) (Suess' figure of this is possibly a branched form—a *Cyrtograptus*,—but quite unidentifiable from his

drawings); (11) *Gr. Sedgwickii;* (12) *Gr. tænius ;* (13) *Gr. Becki;* (14) *Gr. Nilssoni ;* (15) *Gr. convolutus* (?). Under the name (16) *Gr. colonus* (Barrande) he figures several specimens which probably represent various aspects of *Mono. vomerinus* (Nicholson). In addition to these forms, which had been already described by previous authors, Suess figures two new species in this group, viz. (17) *Gr.* **dubius** and (18) *Gr.* **falx**. Of these, however, only the first is identifiable at the present day as a distinct species.

In his Group 2 (*Graptolithus*) Suess describes (19) *Gr. turriculatus ;* (20) *Gr. proteus*, and a new form (21) *Gr.* **armatus**.

In his Group 3 (*Rastrites*) he includes (22) *Gr. Linnæi;* (23) *Gr. fugax ;* (24) *Gr. peregrinus ;* and a new species, (25) *Gr.* **Barrandei**.

1851.
Richter,
"Ueber Thüringische Graptolithen,"
'Zeit. d. Deutsch. geol. Gesell.,' Bd. iii.

In 1851 Richter published a second paper, entitled "Ueber Thüringische Graptolithen." This paper is supplementary to the one previously published by him in 1850, and while the views of Barrande as regards the structure of the Graptolites are, to a large extent, incorporated in it by Richter, they are in many particulars amplified by the results and conclusions drawn from his own researches.

The paper contains a descriptive list of species obtained by him from the Alum shales of Thüringia, viz. (1) *Gladiolites Geinitzianus ;* (2) *Diprion palmeus ;* (3) *D. ovatus* (which he regards as probably only a variety of *D. palmeus* or *D. folium*); (4) *Gr. priodon ;* (5) *Gr. colonus ;* (6) *Gr. Becki ;* (7) *Gr. nuntius ;* (8) *Gr. Halli ;* (9) *Gr. bohemicus ;* (10) *Gr. testis ;* (11) *Gr. chimæra ;* (12) *Gr. proteus ;* (13) *Gr. turriculatus ;* (14) *Rastrites gemmatus ;* (15) *R. Linnæi ;* (16) *R. peregrinus.*

Richter confirms Barrande's views on almost all points of structure, and, in addition, he draws attention (simultaneously with Scharenberg) to the special organ now known as the "sicula" (Lapworth), which he calls the *fuss* (foot, base, or pedestal). His figures (1 to 3) represent it as being jointed. He regards it as a "prolongation of the axis," generally directed upwards, but occasionally downwards (*Diprion folium*). In *Gladiolites* and *Diprion* it is always bodkin-shaped; in *Rastrites* spindle-shaped. If this organ is actually a "foot," then he considers Barrande's and Suess' view that the thinner end of the polypary is the younger, and the wider part the older, must be erroneous. He believes that the skeleton of the polypary probably possessed little or no rigidity, and therefore that the form of the polypary, except in *Gr. turriculatus*, was not constant.

Mode of Occurrence.—Richter draws attention to many interesting facts bearing on the mode of occurrence of the Graptolites. He points out that they always lie on the *surface* of the rock, and are never found upright or traversing the shale; and that they are generally arranged quite irregularly—implying, apparently, that they did not live fixed in the mud where they are now found. According to

Richter, the occurrence of such numbers of specimens on these extremely thin layers of rock indicates that the Graptolites were very short-lived, and that the fact that they gradually disappear as the Alum shales thin out, shows that they were confined to deep water.

1851.
Scharenberg,
'Ueber Graptolithen, mit besonderer Berücksichtigung der bei Christiania vorkommenden Arten.'

A remarkable paper published by Scharenberg in 1851, which may be regarded in a sense as a direct outcome of Barrande's memoir, is of great importance, the author criticising fully the observations and views of Barrande in the light of his own researches among the Graptolites from the Christiania district of Norway.

Description of Species.— In this paper Scharenberg describes and figures six species: (1) *Gr. geminus*, (2) *Gr. virgulatus*, (3) *Gr. folium*, (4) *Gr. teretiusculus*, (5) *Gr.* **Barrandei**, and (6) *Gr.* **personatus**, of which the last two only are new. The figures are conscientiously drawn, every imperfection being represented, and are consequently most valuable. But the extreme caution by which not only the figures, but also all the details in his work are characterised, leads him to include under one specific name several forms now regarded as specifically distinct (although, on the other hand, his own two supposed new species cannot be sustained). Under the name of *Gr. teretiusculus* he included at least two distinct species. One of these is the characteristic Arenig-Llandeilo species of *Climacograptus* (subsequently named after him by Lapworth as *C. Scharenbergi*). The specimens described by him as *Gr. folium* are examples of *Phyllograptus.*

Specific Criteria.—Scharenberg prefaced the descriptive portion of his work by a careful analysis of the most important points to be considered in distinguishing different species. As these are of considerable interest, they may here be briefly considered.

1. *Length of Stipe.*—According to Scharenberg this character is not of much importance, owing to the fact that it is difficult to determine when the specimen is complete, and that even fully grown specimens of one and the same species may vary much in size.

2. *Width of Stipe.*—On the other hand, Scharenberg considers that there is a practically constant relation between the width of the cells and the common canal.

3. *General Form of the Polypary.*—Scharenberg regards this character as one necessitating extreme caution in its interpretation, concluding his remarks on the matter as follows:—" The determination of a species founded on the outer form of a Graptolite is only trustworthy when there is only one row of cells, and these cells are distant (*Rastrites*). Teeth, denticles, and appendages of the cell must be considered as distorted or falsely shaped cell apertures, until their normal condition has been proved with certainty in well-preserved specimens, in the same way as

Barrande has done in the case of *Gr. priodon* and *Gr. colonus*." So anxious was Scharenberg to avoid any confusion between normal and abnormal appearances, that it led him into the opposite extreme of misinterpreting several constant specific characters, and attributing them either to the results of deformation or to the special mode of preservation.

4. *Existence and Direction of Axis.*—Scharenberg disagrees emphatically with Barrande's view that the axis is never anything more than a single solid cylinder, the same in a *Diprion* as in a *Monoprion* form. He explains the curious double and vesicular appearance of the axis in some of the specimens of the *D. palmeus* as figured by Barrande, by the theory that it not only represents the true axis itself, but also a part of the common canal, from which the cells have been torn off before fossilisation. In the case of the two-branched forms, such as *Gr. geminus*, Scharenberg points out that the axis must have divided or branched during life. In all double Graptolites he thinks that the axis is invariably straight, while in single-rowed ones it may assume almost any form. He does not consider that the form of the polypary is constant in each species, except perhaps in the case of *Gr. turriculatus*.

5. *The Texture of the Graptolite Stipe.*—Scharenberg points out that this character would be of the greatest importance in determining species if it could be ascertained; but, unfortunately, it can very rarely be observed. In the case of *Gladiolites*, its peculiarities quite justify this form being made the type of a new genus. He observes the horizontal grooves and markings (growth-lines) on the cells in certain specimens of *Graptolithus* as "small thickened rings, like the texture of many snail shells;" but, like Barrande, he does not suggest that they are growth-lines.

6. *Number of Cell Rows, and the Angle which the Cells make with the Axis.*—Scharenberg does not regard either of these characters as of much systematic importance. He holds that Barrande's separation of the Graptolites into *Monoprion* and *Diprion* sections is also of little value, owing to the difficulty of determining in scalariform views to which division a specimen belongs.

7. *The Inclination of the Cells to the Common Canal, and their Direction.*—These characters are of great moment, especially in those forms in which the cells are in close contact.

8. *The Distance of the Cells apart from each other.*—This is also a reliable method of distinction of species; but Scharenberg does not agree with Barrande that it is of generic value, as in the case of *Rastrites*.

9. *The Form of the Cells and their Apertures.*—This is "undoubtedly the most important criterion for the distinction of species."

10. *The Breadth of the Common Canal in Relation to the Length of the Cells.*—This is a character which deserves more attention than it has hitherto received.

The most important part of Scharenberg's paper is the general preface, dealing

with the classification, structure, and mode of life of the Graptolites, for in these particulars Scharenberg added very considerably to the observations made by Barrande on the subject.

Classification.—As regards the classification of the Graptolites, he considers that Barrande's suggested division into *Monoprion* and *Diprion* is quite inadequate, for it excludes all the branching forms, such as *Gr. geminus*, *Gr. sextans*, etc., of the existence of which he himself has no doubt whatsoever. Bronn's (? Richter's) classification into spiral, straight, double-row, and twin-like forms Scharenberg regards as better, but nevertheless not quite satisfactory, as many Graptolites are at first curved and then become straight. As *Gladiolites* has no distinct axis, and its structure is so peculiar, and without parallel, Scharenberg considers that it should be separated from the Graptolites altogether.

Structure.—From the structural point of view, Scharenberg's views as to the development of the *Diprion* forms are of interest. They were antagonistic to those previously held by the majority of graptolithologists, but they have subsequently been more or less confirmed by modern research. He points out that in *Diprion* the cells alternate without exception. "It may be concluded from this that in the development of these animals two cells never arose at the same time, and consequently there is no essential difference between the Graptolites which are distinguished as having one row and those which have two rows of cells."

As regards the nature of the skeleton of the Graptolites, Scharenberg agrees with Barrande that it was horn-like, and that it possessed a "high degree of flexibility;" but owing to its easy destructibility, Scharenberg, as has been already mentioned, considered that many original characters, such as spines at the cell apertures, etc., were merely the result of decomposition.

Affinities.—With respect to the affinities of the Graptolites, Scharenberg held that they were most closely allied to the *Pennatulidæ*. He pointed out, however, as did Prout in the same year, that they differed from the *Pennatulidæ* in having an external and not an internal skeleton.

Mode of Growth.—Scharenberg strongly criticises Barrande's views as to the mode of growth of the Graptolites. He considers that many, especially the branched and double-rowed forms, were fixed in the mud by a kind of "stem," and that consequently the cell apertures opened upwards. If this were the case, then the narrow end, instead of being, as believed by Barrande, the youngest, must be the oldest part, and growth must have proceeded from below upwards. This special mode of growth would indeed be analogous to that in the *Pennatulidæ*, to which the Graptolites are closely related. He also points out, in support of this view, that the narrowness of the polypary does not necessarily imply that the smaller cells are the youngest, for in some species (*G. ovatus*) the polypary narrows at both ends alike.

Genus TETRAGRAPTUS, *Salter.*

863. *Tet ragrapsus,* Salter, "Note on the Skiddaw Slate Fossils," Quart. Journ. Geol. Soc., vol. xix, p. 137.

Polypary bilaterally symmetrical, consisting of four uniserial main stipes, which are produced by dichotomous division from a primitive "*Didymograptus stage;*" these stipes may grow upward, outward, or downward.

Thecæ.—Simple cylindrical or subcylindrical tubes expanding slightly in the direction of their apertures, inclination variable, usually in contact for a considerable portion of their length.

The polypary is characterised by the possession of stipes of two orders only. Those of the first order are short, and constitute together in this genus the "funicle" of the earlier authors; those of the second order are long, and form the four main stipes of the polypary. These four main stipes may ultimately grow in different directions in the several species, but they invariably originate in a primitive *Didymograptus stage*, which is usually horizontal.

The earliest theca develops from the sicula in a manner precisely similar to that described for *Didymograptus* (*ante*, pp. 6, 7). It may originate (*a*) near the apex of the sicula (*T. Bigsbyi*), or (*b*) close to the aperture itself (*T. quadribrachiatus*). The crossing canal and second theca are also developed on the *Didymograptus* plan. After the development of one or more thecæ, however, a dividing wall (see Fig. 40 *a*) makes its appearance in each young stipe; and hence from one theca on each stipe two thecæ are developed. These grow apart from each other, and originate two stipes on each side of the sicula, instead of one only, as is the case in *Didymograptus.*

The *Didymograptus stage* is invariably short-lived, but it seems to persist longer in some forms of *Tetragraptus* than in others. In *T. Bigsbyi*, for example, as Holm has shown ('Geol. Fören. Förhandl.,' vol. xvii, p. 319), the dichotomous division takes place in the two thecæ which are first developed (th. 1^1 and th. 1^2); and thus the two stipes of the first order are reduced to a minimum as regards their length; while in such a form as *T. quadribrachiatus* the earliest thecæ remain undivided, and the second or third thecæ on each side of the sicula (th. 2^1 and 2^2 or 3^1 and 3^2) undergo division; so that the stipes of the first order in the former case consist each of one theca, and in the latter case of two or of three thecæ. After division the development and growth of the four main stipes proceed in the normal manner of those of *Didymograptus.*

The *Tetragrapti*, like the *Didymograpti*, fall into natural serial groups, according to the ultimate direction of their stipes; thus we have a **horizontal**

series, a **reclined series,** a **dependent series,** and, if we include the genus *Phyllograptus*, a **scandent series.**

The genus *Phyllograptus*, which is characterised by the possession of four stipes of the type of those of *Tetragraptus*, but conjoined by their dorsal margins, has hitherto been regarded as a distinct genus, and by some even as the type of a distinct family. Recent discoveries, however, have shown a practically complete gradation, both in the mode of development and in structure, between *Phyllograptus* and *Tetragraptus*. In this work we retain *Phyllograptus* as a genus, on account of its characteristic habit—which is that of a *Diplograptus*,—but we group it as a member of the family of the Dichograptidæ (see *postea*), and we leave to future research the possible demonstration that it is more naturally classed as a *scandent* Tetragraptid.

The species here included in the horizontal, dependent, and reclined serial groups of *Tetragraptus* are as follows:

Horizontal Series.—Group I.	Type *T. quadribrachiatus.*	
		T. quadribrachiatus.
		T. crucifer.
		T. Headi.
		T. Amii.
Dependent Series.—Group II.	Type *T. fruticosus.*	
		T. fruticosus.
Group III.	Type *T. pendens.*	
		T. pendens.
		T. Postlethwaitii.
Reclined Series.—Group IV.	Type *T. serra.*	
		T. serra.
		T. reclinatus.
Group V.	Type *T. Bigsbyi.*	
		T. Bigsbyi.

Horizontal Series.

Tetragrapti with two pairs of approximately straight and horizontal main stipes, which make an angle of divergence of 180° with the line of the nema.

Group I.—Type *T. quadribrachiatus.*

Tetragrapti in which the main stipes are spread out in a horizontal plane; they are commonly several centimetres in length. Their thecæ are inclined at high angles, and are in contact for the greater part of their length.

Tetragraptus quadribrachiatus (Hall). Plate V, figs. 1 *a—d*.

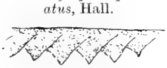
1858. *Graptolithus quadribrachiatus*, Hall, Geol. Survey Canada Rep., 1857, p. 125.
1863. *Tetragrapsus crucialis*, Salter, Quart. Journ. Geol. Soc., vol. xix, p. 137, fig. 8 *b*.
1865. *Graptolithus quadribrachiatus*, Hall, Grapt. of Quebec Group, p. 91, pl. v, figs. 1—5, pl. vi, figs. 5, 6.
1868. *Tetragrapsus quadribrachiatus*, Nicholson, Quart. Journ. Geol. Soc., vol. xxiv, p. 131.
1874. *Tetragraptus quadribrachiatus*, Etheridge, jun., Ann. Mag. Nat. Hist., ser. 4, vol. xiv, p. 1.
1875. *Tetragraptus quadribrachiatus*, Hopkinson and Lapworth, Quart. Journ. Geol. Soc., vol. xxxi, p. 649, pl. xxxiii, figs. 9 *a*, *b*.
1877. *Graptolithus (Didymograpsus) quadribrachiatus*, M'Coy, Prodromus Pal. Victoria, pt. 1.
1898. *Tetragraptus quadribrachiatus*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 485.

Main stipes 2·5—7·5 cm. in length, approximately straight and rigid, somewhat slender at origin, but increasing gradually up to a maximum width of 2·6 mm. Thecæ ten to nine in 10 mm., inclined 30° to 40°, four times as long as wide, free one half to one third their length. Apertural margins normal, straight, or with slight curvature.

Description.—The stipes of the first order are short, and occasionally enclosed in a disc, though this is often absent. The main stipes may attain a length of 7·5 cm. They increase in width from about ·6 mm. at their origin to a maximum of 2·6 mm. Smaller examples of the species whose width is 1·2—1·5 mm. are of commoner occurrence.

All details concerning the structure of the proximal end are obscure in our British specimens, but it appears certain that the dichotomous division of the stipes of the first order does not take place until at least two thecæ have been already developed on each side of the sicula. The apertural part of the sicula is all that is usually seen.

FIG. 34.—*Tetragraptus quadribrachiatus*, Hall.



Distal thecæ. Enlargement of part of Pl. V, fig. 1 *d*.

Each theca measures about 1·6 mm. in length, the outer wall is slightly curved, and, as a general rule, each theca is free for about half its length near the proximal end of the polypary, but rather less distally, and in large specimens for not more than one third its length. It is, however, often very difficult to determine any of the characters of the thecæ in the proximal parts of the main stipes, since they are generally preserved with their apertures embedded in the rock, and thus only the dorsal walls of the stipes are presented to the observer. The apertural angle, though typically 90°, varies with compression from 95° to 100°.

Affinities.—*T. quadribrachiatus* is a characteristically slender species; it may be regarded as allied in general form to *T. Headi* and *T. crucifer;* indeed, it is probable that many of the larger and wider forms often erroneously referred to *T. quadribrachiatus* should be relegated to *T. crucifer,* from which *T. quadribrachiatus* differs chiefly in the width of its stipes. It is distinguished from *T. Headi* in the character of the proximal end and by the form of the thecæ. The presence or absence of a disc, in our opinion, is not a character of specific importance.

Horizon and Localities.—Middle Arenig, Middle Skiddaw Slates (Middle and Upper beds).

Lake District: Barf; Outerside; Bassenthwaite Common; Randal Crag, Skiddaw; Carlside Edge, Skiddaw; Scawgill; Scale Hill, Crummuck; N.E. Grisedale Pike; Raven Gill. *St. David's District:* Whitesand Bay. *S. Scotland:* Bennane Head, Ballantrae.

Associates, etc.—*T. quadribrachiatus* is found in the Skiddaw Slates associated with *T. crucifer, Didymog. Nicholsoni, D. gibberulus, Azygog. suecicus,* and *Cryptog. Hopkinsoni.* It is seldom well preserved; the best specimens known to us come from the Skiddaw Slates, and are in the collections of the Woodwardian Museum, the Keswick Museum, and in Postlethwaite's private collection.

Tetragraptus crucifer (Hall). Plate V, fig. 2.

1858. *Graptolithus crucifer,* Hall, Geol. Survey Canada Rep., 1857, p. 125.
1865. *Graptolithus crucifer,* Hall, Grapt. of Quebec Group, p. 92, pl. v, fig. 10.
1865. *Tetragrapsus crucifer,* Nicholson, Quart. Journ. Geol. Soc., vol. xxiv, p. 144.
1898. *Tetragraptus crucifer,* Elles, ibid., vol. liv, p. 488, fig. 12.

Main stipes long, about 8 cm. in length, approximately straight and rigid, but widening rapidly to a maximum width of 4 mm. Thecæ about eight in 10 mm., inclined at 45°, four times as long as wide, and having a length of about 3—4 mm.; in contact for three quarters their extent. Apertural margins normal, concave.

Description.—A small disc generally encloses both stipes of the first order, which are short, and also the proximal portions of the main stipes. In shape this disc, while probably originally square in form, is commonly oblong after compression, averaging 7 by 5 mm.; it is almost invariably slightly prolonged up the stipes.

Details of the plan of structure of the proximal end have not been observed, and the thecal characters are also obscure.

Affinities.—In general form *T. crucifer* resembles both *T. quadribrachiatus* and *T. Headi.* As already pointed out, it seems probable that the larger and wider forms often referred to *T. quadribrachiatus* would be more legitimately included in

the present species. *T. crucifer* may be distinguished from *T. Headi* by the form of the proximal end, and the slightly different characters of the thecæ.

Horizon and Locality.—Arenig, Middle Skiddaw Slates (Upper beds).

Lake District: Barf, near Keswick.

Associates, etc.—*T. crucifer* occurs associated with *Az. suecicus* and *T. quadribrachiatus.*

The most characteristic specimen of this species known to us was found by Postlethwaite in the Skiddaw Slates of Barf, and is now in his collection.

Tetragraptus Headi (Hall). Plate V, figs. 3 *a*, *b*.

1858. *Graptolithus Headi,* Hall, Geol. Survey Canada Rep., 1857, p. 127.
1865. *Graptolithus Headi,* Hall, Grapt. of Quebec Group, p. 94, pl. vi, fig. 8.
1868. *Tetragrapsus Headi,* Nicholson, Quart. Journ. Geol. Soc., vol. xxiv, p. 131.
1877. *Graptolithus (Didymograpsus) Headi,* M'Coy, Prodromus Pal. Victoria, Dec. v, p. 39, pl. L.
1898. *Tetragraptus Headi,* Elles, Quart. Journ. Geol. Soc., vol. liv, p. 486, fig. 11.

Main stipes 5—26 cm. in length, approximately straight and rigid; somewhat slender at origin, but increasing in width to a maximum of 3 mm. A large disc generally present. Thecæ nine to ten in 10 mm., inclined at 40°, three to four times as long as wide, in contact for more than three quarters their length. Apertural margins normal, concave, with mucronate denticles.

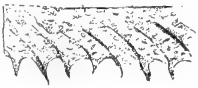
Description.—In the forms which have a disc the stipes are preserved, as a rule, with the dorsal side uppermost, though in exceptional cases the thecæ are visible. In those examples, however, which possess no disc, the profile view of the thecæ is well seen. The stipes of the first order are exceedingly short—shorter, in fact, than in either of the allied species (*T. quadribrachiatus* and *T. crucifer*). This would seem to indicate that the earliest developed thecæ (th. 1^1 and th. 1^2) are unusually small, and that the dichotomous division of the stipes takes place within them. The main stipes, on the other hand, are often very long, and may indeed attain a length of as much as 26 cm.

FIG. 35 *a.*—*Tetragraptus Headi,* Hall.

Proximal end, showing portion of a disc. North of Talfan, Whitland. Coll. Woodwardian Museum.

The disc, which seems to be present in most cases, is nearly square, and has more or less straight sides. In the largest specimens examined it was fully 17 mm. square, but it is often incompletely preserved. It is always slightly extended along the stipes, notably so in young forms. In one adult specimen in Postlethwaite's collection there is a very prolonged "*alation*" of this kind, but this is not so pronounced in other specimens.

FIG. 35 *b*.—*Tetragraptus Headi*, Hall.



Distal thecæ. North of Talfan, Whitland. Coll. Woodwardian Museum.

The thecæ have an average length of 3·2 mm.; they are in contact for rather more than three-quarters their length in the distal parts of the stipes, but for rather less near the proximal end.

Affinities.—*T. Headi* resembles in general shape *T. quadribrachiatus* and *T. crucifer*, but the size of the stipes seems to distinguish it from the former, while the characters of the thecæ and the extreme shortness of the stipes of the first order appear to separate it from the latter. But there can be no doubt that *T. Headi* and *T. crucifer* are very closely allied, and they may possibly some day be proved to be identical.

Horizon and Localities.—Arenig, Middle Skiddaw Slates.

Lake District: Randal Crag, Skiddaw; Barf, near Keswick. *S. Scotland:* Bennane Head, Ballantrae. *S. Wales:* North of Talfan, Whitland.

Associates, etc.—This form occurs in the Skiddaw Slates, where it is associated with *Didymograptus hirundo* and *D. gibberulus*. According to the officers of H.M. Geological Survey it has also been found in the Arenig rocks of South Scotland.[1] Good specimens have been met with in South Wales, associated with various Dendrograpti, and are now in the Woodwardian Museum. The largest example is from the Skiddaw Slates of Randal Crag, and is in Lapworth's collection.

Tetragraptus Amii, Lapworth MS. Plate V, figs. 4 *a*—*c*.

1865. *Graptolites bryonoides*, Hall, Grapt. of Quebec Group, pl. iv, figs. 9, 10.

Main stipes from 2·5 to 5·5 cm. in length, approximately straight and rigid, slender at origin, but widening rapidly to an average maximum of 3 mm. Thecæ nine to ten in 10 mm., inclined at 45°, three to four times as long as wide, and free one quarter their length. Apertural margins normal, concave.

Description.—The main stipes are, as a general rule, from 2·5 to 3·5 cm. long, though longer ones may occur. All show the characteristic rapid increase in width near their initial extremities, though some of the smaller specimens never attain the maximum breadth; a width of 3 mm. being characteristic of the forms most commonly met with. All, however, show a slight diminution in breadth at their extreme distal end, owing to the incomplete growth of the thecæ at that point.

The sicula has a length of about 2 mm., but it is only indistinctly indicated, as a general rule, and details of the structure of the proximal end are likewise obscure.

[1] 'Memoirs of the Geol. Survey,' "The Silurian Rocks of Britain," vol. i, Scotland, p. 661.

FIG. 36.—*Tetragraptus Amii*, Lapw. MS.

Distal thecæ. Enlargement of part of Pl. V, fig. 4 *a*.

The thecæ vary in size and number according to their position on the main stipes. When completely developed they have an average length of about 3 mm., their walls are somewhat curved, and they are approximately uniform in width throughout their length; the angle of inclination varies from about 30° in the initial region of each theca to 45° near the aperture; this is consequent upon the curvature of the thecal wall.

Affinities.—*T. Amii* forms a connecting link between Groups 1 and 4. In general form and manner of growth it is closely related to *T. quadribrachiatus*, but differs in the greater flexibility of the stipes, in their rapid widening, and in the characters of the thecæ. In these two latter characteristics it closely approximates to *T. serra*, from which it differs, however, in general shape and mode of growth.

Remarks.—This form was included by Hall in *T. serra* (= *T. bryonoides* (Hall), 'Grapt. of Quebec Group,' p. 84), and though long regarded as distinct by Lapworth no description has hitherto appeared. It was first recognised in specimens from Canada, and is named after the palæontologist Dr. Henri Ami, of the Canadian Geological Survey.

Horizon and Localities.—Arenig, Middle Skiddaw Slates.

Lake District: Randal Crag, Skiddaw; White House Fell, Skiddaw; E. Dodd Wood. *S. Wales:* Whitesand Bay. *N. Wales:* Aberdaron.

Associates, etc.—*T. Amii* occurs in the Skiddaw Slates of the north of England associated with *Tetrag. serra* and *Didymog. extensus;* it is also found in Wales. The best specimens known to us are in the Woodwardian Museum.

DEPENDENT SERIES.

Tetragrapti with two pairs of main stipes diverging downward, but which all tend to become approximately parallel.

Group II.—Type *T. fruticosus.*

Tetragrapti in which the stipes are directed subvertically downward but diverge at their distal extremities, and increase in width throughout their length; the thecæ are inclined at a moderate angle, and are in contact for the greater part of their extent.

Tetragraptus fruticosus (Hall). Plate VI, figs. 2 *a*, *b*.

1858. *Graptolithus fruticosus*, Hall, Geol. Survey Canada Rep., 1857, p. 128.
1865. *Graptolithus fruticosus*, Hall, Grapt. of Quebec Group, p. 90, pl. vi, figs. 1–3.

1874. *Didymograptus* (?) *fruticosus*, Etheridge, jun., Ann. Mag. Nat. Hist., ser. 4, vol. xi, p. 1.
1877. *Graptolithus* (*Didymograpsus*) *fruticosus*, M'Coy, Prodromus Pal. Victoria, p. 13, pl. i, figs. 9—14.

Main stipes from 1·5 to 2·5 cm. in length, directed more or less vertically downward for greater part of their length, but diverging towards their distal extremity; increasing in width gradually and persistently up to a maximum of 2 mm. Sicula conspicuous. Thecæ seven in 10 mm., inclined 30°—35°, two or three times as long as wide, free for one third their length. Apertural margins normal, concave, mucronate.

Description.—The persistent increase in width of the stipes is extremely characteristic of the species; the width opposite the aperture of theca 1^1 is only 1 mm., but it increases steadily thereafter up to a maximum of 2 mm.

FIG. 37.—*Tetragraptus fruticosus*, Hall.

Proximal end, obverse view. Enlargement of Pl. VI, fig. 2 *b*.

The sicula measures 2 mm., and the first theca (th. 1^1) originates near the apex. The dichotomous division of the stipes of the first order appears to take place after the development of two thecæ on each side of the sicula.

Hall gives the length of the sicula as 12·7 mm. ($\frac{1}{2}$ inch), but it is clear from his figures that this measurement included a considerable portion of the nema or virgula; the true sicula, so far as we have seen, never exceeds 2 mm. in length.

The thecæ are comparatively remote, and average about seven in 10 mm. in the mature parts of the stipes. This inclination increases slightly with age, those thecæ nearest the sicula being inclined at about 30°, while those in the more distal parts have an inclination of about 35°. They are about twice as long as wide near the sicula, but about three times as long in the fully developed parts of the stipe; the overlap increases from mere contact to a maximum of two thirds the length of the thecæ. The aperture is concave and mucronate when well preserved, but slight distortions cause it to appear straight and devoid of any mucro.

Affinities.—*T. fruticosus* resembles *T. pendens* in its general form, but may readily be distinguished from it by its greater size, the persistent increase in width of the stipes, the number of thecæ in a given unit of length, and their degree of inclination.

Horizon and Localities.—Arenig.

S. Scotland: Bennane Head, Ballantrae. *Lake District:* Raven Gill.

Associates, etc.—The true *T. fruticosus* has hitherto been recorded only from the Arenig rocks of the Girvan district (Ballantrae), S. Scotland, where it has been found by Lapworth and the officers of H.M. Geological Survey, in whose collections the specimens are preserved. At Ballantrae it occurs associated with

Tetragraptus serra and *Didymograptus* cfr. *filiformis*. It is now, however, known to occur in the Lake District.

Group III.—Type *T. pendens*.

Tetragrapti in which the stipes are directed subvertically downward and are of uniform width throughout their length; the thecæ are closely set, and are in contact for about one half their extent.

Tetragraptus pendens, Elles. Plate VI, figs. 3 *a—d*.

1898. *Tetragraptus pendens*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 491, fig. 13.

Main stipes short, from 12 to 18 mm. in length, directed subvertically downward, ultimately running nearly parallel to each other, and having a uniformly slender width of ·6 mm. throughout their length. Sicula conspicuous. Thecæ nine to twelve in 10 mm., inclined 15°—20°, about three times as long as wide, free one third to half their length. Apertural margins normal, straight, occupying more than half the total width of the polypary.

Description.—The whole polypary is small, the stipes not exceeding 18 mm. in length; they are also more or less uniformly narrow (·6 mm.), and their thecæ are always borne on the inner margins.

Fig. 38.—*Tetragraptus pendens*, Elles.

Proximal end, reverse view, preserved as an impression. Enlargement of Pl. VI, fig. 3 *d*.

The sicula is conspicuous; it measures about 1·6 mm., and the stipes originate in a manner precisely similar to that observed in the Didymograpti of the *dependent series*, but after the development of one theca on each side of the sicula each stipe undergoes dichotomous division, resulting in the production of two pairs of stipes which are similar in every respect.

The thecæ are long, narrow tubes of uniform width; they have an average length of about 1·6 mm.; their outer walls are straight, or show slight concave curvature near the proximal end.

Affinities.—This delicate little species somewhat resembles *T. fruticosus* in its general mode of growth, but may readily be distinguished from that species since—

(1) it is smaller and far more slender,

(2) its stipes are parallel and of uniform width, while those of *T. fruticosus* are divergent distally, and increase in width throughout,

(3) there are more thecæ in a given unit of length, nine to twelve, as compared with seven, in 10 mm.,

(4) the thecæ are inclined at a much lower angle, 15° as compared with 35°.

From all other known Tetragrapti it is distinguished by its form.

Horizon and Locality.—Arenig, Middle Skiddaw Slates.

Lake District.—Barf, near Keswick.

Associates, etc.—*T. pendens* occurs in the Skiddaw Slates, associated with *Azygog. suecicus*, *Didymog. deflexus*, *D. gibberulus*, and *Phyllog.* cfr. *typus*. It has not as yet been recognised elsewhere.

Tetragraptus Postlethwaitii, Elles. Plate VI, figs. 1 *a*, *b*.

1898. *Tetragraptus Postlethwaitii*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 492, fig. 14.

Main stipes 2·5—9 cm. in length; slightly curved, directed more or less vertically downward, and having a uniform width of 1·6 mm. Sicula conspicuous. Thecæ eleven to twelve in 10 mm., inclined 30°, three times as long as wide, in contact half to two thirds their length. Apertural margins normal, straight.

Description.—Both stipes of the first order are very short, but the main stipes often attain a considerable length. One specimen showed stipes with a length 9 cm., but the width never exceeded 1·6 mm.

Fig. 39.—*Tetragraptus Postlethwaitii*, Elles.

Proximal end, reverse view. Enlargement of Pl. VI, fig. 1 *a*.

The sicula has a length of about 2 mm.; the crossing canal is nearly horizontal.

The thecæ are 2 mm. in length; they widen slightly towards their apertures; their outer walls are curved, and the apertural angle is commonly 130° after compression.

Affinities.—*T. Postlethwaitii* resembles *T. fruticosus* and *T. pendens* in its mode of growth, but differs from them in some important characters. It may be distinguished from *T. fruticosus*—

(1) by the absence of widening in the stipes,

(2) in the lower angle of inclination of the thecæ, and the greater number in a given unit of length.

It differs from *T. pendens*—

(1) in its larger size,

(2) in the higher angle of inclination of the thecæ, and the greater number in a given unit of length.

Horizon and Localities.—Arenig, Middle Skiddaw Slates.

Lake District: Carlside Edge; Barf, near Keswick.

Associates, etc.—The associates of *T. Postlethwaitii* are at present unknown. All the specimens known at present come from the Skiddaw Slates, and with one exception are in Postlethwaite's collection.

Reclined Series.

Tetragrapti with two pairs of approximately straight stipes converging upward and backward upon the nema, and making with it an angle of more than 180°.

Group IV.—Type *T. serra.*

Tetragrapti in which the main stipes are straight and directed obliquely upward; they are commonly short. The sicula is conspicuous. The thecæ are inclined at high angles, and are in contact for the greater part of their length.

Tetragraptus serra (Brong.). Plate VI, figs. 4 *a—f*.

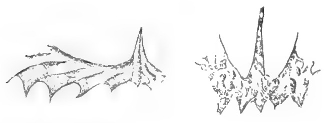
1828. *Fucoides serra*, Brongniart, Hist. Veget. Foss., vol. i, p. 71, pl. vi, figs. 7, 8.
1853. *Didymograpsus caduceus*, Salter (pars), Quart. Journ. Geol. Soc., vol. ix, p. 87, fig. 1 *a*.
1858. *Graptolithus bryonoides*, Hall, Geol. Survey Canada Rep., 1857, p. 126.
1863. *Tetragrapsus [bryonoides]*, Salter, Quart. Journ. Geol. Soc., vol. xix, p. 137, fig. 8 *a*.
1863. *Didymograpsus caduceus*, Salter, ibid., fig. 13 *b*.
1865. *Graptolithus bryonoides*, Hall, Grapt. of Quebec Group, p. 84, pl. iv, figs. 1—8, 11.
1868. *Tetragrapsus bryonoides*, Nicholson, Quart. Journ. Geol. Soc., vol. xxiv, p. 131.
1868. *Didymograptus caduceus*, Nicholson, ibid., p. 133.
1874. *Tetragraptus bryonoides*, Etheridge, jun., Ann. Mag. Nat. Hist., ser. 4, vol. xiv, p. 1.
1875. *Tetragraptus serra*, Hopkinson and Lapworth, Quart. Journ. Geol. Soc., vol. xxxi, p. 650, pl. xxxiii, fig. 10.
1875. *Tetragraptus Halli*, Hopkinson, ibid., figs. 11 *a*, 11 *b*.
1877. *Graptolithus (Didymograpsus) bryonoides*, M'Coy, Prodromus Pal. Victoria, dec. 1.
1898. *Tetragraptus serra*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 490.

Main stipes 2·5—5 cm. in length, approximately straight, narrow at their origin, but widening abruptly and rapidly to a maximum breadth of 3·2 mm. Sicula conspicuous; thecæ eight to nine in 10 mm., inclined at 45°, three to four times as long as wide, free one third to one fourth their length. Apertural margins normal, concave.

Description.—The stipes of the first order attain together a length of about 2 mm. The main stipes resulting from the dichotomous division of these do not, as a general rule, exceed 5 cm. in length. These stipes are quite narrow at their

origin, but widen rapidly, and are generally found to have attained their maximum width after the third or fourth theca; the usual diminution takes place towards the distal extremities. The width attained in different individuals varies greatly; the average width at origin is about 1 mm. (or less), but while in some individuals a width of 2·1 mm. is never exceeded, in others a maximum of 3·2 mm. is attained.

FIGS. 40 *a* and *b*.—*Tetragraptus serra*, Brongniart.



a *b*

a. Proximal end, obverse view, preserved partly as an impression, showing the dividing wall originating in th. 1[1]. Bennane Head, Ballantrae. Coll. Lapworth.
b. Proximal end, showing part of nema. Outer-side. Coll. British Museum (Natural History), S. Kensington.

The sicula is rather more than 2 mm. in length, and is proportionately narrow. The first theca appears to originate near the apex of the sicula, in a manner somewhat resembling that of *D. gibberulus;* but other details are obscure. Both the earliest thecæ (th. 1^1 and th. 1^2, forming the stipes of the first order) are small as compared with those subsequently developed on the main stipes, and dichotomous division takes place within them.

The thecæ on the main stipes vary in number according to their position on the stipe, and the size and age of an individual. Near the proximal end of the main stipes there may be ten in 10 mm., but distally the number rarely exceeds eight. When fully developed the thecæ are about 3·2 mm. in length; they are somewhat curved, and are widest at their apertures. The inclination varies from 30° to 50° owing to curvature, the thecæ being inclined at 30° in their central regions, but then curving upward so as to make, near their apertures, an angle of from 45° to 50° with the general direction of the stipe. In some specimens the growth-lines are well seen.

FIG. 40 *c*.—*Tetragraptus serra*, Brong.

Thecæ in relief, showing growth-lines. Bennane Head, Ballantrae. Coll. Lapworth.

Remarks.—Hall's descriptions of his *G. bryonoides* seem to have been drawn up from two forms—one in which the stipes are directed obliquely upward, and one in which the stipes are spread out in what may be termed a "*quadribrachiatus*" fashion. This implies two different modes of growth, and there are also other differences. It is therefore necessary to distinguish between the two forms; the one with the stipes directed obliquely upward is the form which Hall considered to be identical with *Tetragraptus serra*, an opinion in which we agree. The other is that which is here designated *T. Amii.*

Certain examples of *Tetragraptus* from S. Wales, described by Hopkinson ('Quart. Journ. Geol. Soc.,' xxxi, pl. xxxiii, fig. 11) as *T. Halli*, we believe to be greatly compressed specimens of *T. serra.*

Affinities.—*T. serra*, as here restricted, is readily recognisable; it can hardly be said to closely resemble any other species as yet known, and should always be

readily distinguished from *T. Bigsbyi* by its general shape and the fewer thecæ in a given unit of length.

Horizon and Localities.—Arenig, Middle Skiddaw Slates (Upper beds).

Lake District: Randal Crag; Bassenthwaite Sand-beds; Outerside; Gibraltar; Great Knot. *St. David's:* Whitesand Bay; north of Talfan, Whitland. *S. Scotland:* Bennane Head, Ballantrae.

Associates, etc.—*T. serra* appears to be particularly abundant in the Skiddaw Slates, where it occurs associated with *T. Amii*, *D. extensus*, etc.; it has been recorded by the Geological Survey from the Arenig beds of S. Scotland (*loc. cit. supra*), and is also present in S. Wales, where it is associated with numerous *Dendrograpti.* There are good specimens of it in the collections of the British Museum, the Woodwardian Museum, and in Lapworth's private collection.

Tetragraptus reclinatus, sp. nov. Plate VI, figs. 5 *a—e*.

Stipes short, from 12 to 19 mm. in length, approximately straight, directed obliquely upward, very narrow at origin, and with a uniformly narrow width (2 mm.) for the greater part of their length. Sicula conspicuous. Thecæ twelve to thirteen in 10 mm., inclined at 45°, three times as long as wide, in contact two thirds their length. Apertural margins normal, straight.

Description.—The stipes grow upward at a wide angle from each other; those of the first order do not exceed 5 mm. in width. Dichotomous division appears to take place after the development of th. 2^1 and th. 2^2, though this is uncertain. Thereafter the width of the stipes increases to 2 mm., and this width is maintained for the remainder of their length.

FIG. 41.—*Tetragraptus reclinatus*, sp. nov.

Proximal end, reverse view. Enlargement of Pl. VI, fig. 5 *a*.

The sicula has a length of about 1·5 mm., and the first theca originates a short distance below its apex. The average length of the thecæ in the distal portions of the stipes is 1·6 mm.

Affinities.—*Tetragraptus reclinatus* resembles *T. serra* in general shape, but is far more slender than that species, and thus may be readily distinguished from it; further there are a greater number of thecæ in the same unit of length.

Horizon and Localities.—Arenig, Middle Skiddaw Slates.

Lake District: Whinlatter; Carlside Edge.

Associates.—This species has, up to the present time, only been recorded from the Skiddaw Slates, where it is not an abundant form. The best specimens have been collected by Postlethwaite, and are in his collection.

Group V.—Type *T. Bigsbyi.*

Tetragrapti in which the stipes are flexed and are directed outward or curve backward and inward; they are commonly short and wide; the sicula is conspicuous; the thecæ are inclined at high angles, and are in contact for the greater part of their length.

Tetragraptus Bigsbyi (Hall). Plate VI, figs. 6 *a—e*.

1858. *Phyllograptus similis*, Hall, Geol. Survey Canada Rep., 1857, p. 140.
1865. *Graptolithus Bigsbyi*, Hall, Grapt. of Quebec Group, p. 86, pl. xvi, figs. 22—30.
1895. *Tetragraptus Bigsbyi*, Holm, Geol. Fören. Förhandl., vol. xvii, p. 319.
1898. *Tetragraptus Bigsbyi*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 489.

Main stipes short and wide, typically curved, resulting in a polypary of varied form, narrowest at their origin, but widening quickly to their maximum width of about 3·2 mm. Sicula long and conspicuous. Thecæ fourteen to thirteen in 10 mm., inclined at high angles, four times as long as wide, in contact for almost their entire length. Apertural margins slightly concave, and with mucronate denticles.

Description.—Perhaps the commonest form of the polypary, as shown when flattened upon the rock, is best described as a broad oval, truncated at its upper end in most specimens, but occasionally nearly complete. There is a decided tendency on the part of some stipes to come into contact at their distal extremities, and in a few examples actual adhesion, and possibly fusion, appear to have occurred (Pl. VI, figs. 6 *d*, *e*). Examples, however, with stipes which diverge continuously, are very common. The phenomenon of possible fusion is of great interest when regarded in connection with *Phyllograptus* (see *ante*, p. 56), but it cannot as yet be regarded as proved in this species. Should it be possible to do this at any future time, it might be advisable to separate forms possessing this characteristic, as Marr and Nicholson have suggested ('Geol. Mag.,' dec. 4, vol. ii, p. 538), under the name of *T. inosculans.*

The curved stipes in *T. Bigsbyi* are usually short; they never exceed 19 mm. in length, and forms with stipes of about 12·5 mm. are more common. At their origin the stipes are only about 1 mm. wide, and the increase up to 3·2 mm. takes place rapidly. They are wide in proportion to their length, and their ventral margins are always convex, though the rate of curvature varies in different individuals.

The sicula is about 2·3 mm. in length, and the proximal part of the polypary has a similar structure to that of *D. gibberulus;* but whereas the earliest thecæ in that species are longer than any of those subsequently developed, those first developed in *T. Bigsbyi* are the shortest. Holm's work (*loc. cit.*) on the structure of this species goes to show that the earliest theca arises from the sicula near its apex, and the length of the two stipes of the first order ("funicle") is reduced to a minimum, for dichotomous division appears to take place within the earliest formed thecæ, th. 1^1 and th. 1^2.

FIG. 42 *a.*—*Tetragraptus Bigsbyi*, Hall.

Proximal end, preserved as an impression. Enlargement of Pl. VI, fig. 6 *b*.

FIG. 42 *b.*—*Tetragraptus Bigsbyi*, Hall.

Distal thecæ, preserved as an impression. Enlargement of Pl. VI, fig. 6 *b*.

The thecæ are at first nearly at right angles to the general direction of the main stipes; those developed later have an initial angle of 40°—50°, but curve so that near its aperture the theca has an inclination of 60°—70° to the general direction of the stipe. The thecæ are widest at their apertures, and the apertural angle is markedly obtuse after compression, averaging about 140° with the general direction of the stipe.

Affinities.—*T. Bigsbyi* is easily recognisable as a general rule, as it is unlike any other known form of *Tetragraptus*, but when preserved so as to reveal two stipes only, it seems often to have been confused with *D. gibberulus.* These two forms should, however, be readily separated, since the stipes of *T. Bigsbyi* are *narrowest* at their proximal ends, while those of *D. gibberulus* are *widest* in that region.

Horizon and Localities.—Arenig, Lower and Middle Skiddaw Slates.

Lake District: Randal Crag, Skiddaw; Gibraltar; White House Fell, Skiddaw; Bassenthwaite Sand-beds; Outerside; Troutbeck. *S. Scotland:* Bennane Head, Ballantrae.

Associates, etc.—*T. Bigsbyi* occurs in abundance in the lower parts of the Skiddaw Slates, and has been found at Barf, associated with *Bryog. Kjerulfi*, var. *cumbrensis*, and at Outerside with *D. Nicholsoni.* It is also recorded by the Geological Survey (*loc. cit.*) from the Arenig rocks of Ballantrae.

Numerous specimens are in the collection of the Woodwardian Museum, the Keswick Museum, and in Postlethwaite's and Lapworth's private collections.

SPECIFIC CHARACTERS OF FORMS BELONGING TO THE GENUS *Tetragraptus*.

	Horizontal series.				Dependent series.			Reclined series.		
	Group I.				Group II.	Group III.		Group IV.		Group V.
	T. quadribrachiatus.	*T. crucifer.*	*T. Headi.*	*T. Amii.*	*T. fruticosus.*	*T. pendens.*	*T. Postlethwaitii.*	*T. serra.*	*T. reclinatus.*	*T. Bigsbyi.*
Character of stipes .	Horizontal, straight	Horizontal, straight	Horizontal, straight	Horizontal, straight	Pendent, flexed	Pendent, straight	Pendent, straight	Reclined, straight	Reclined, straight	Reclined, flexed
Maximum width of stipes	2·6 mm.	4 mm.	3 mm.	3—4mm.	2 mm.	0·6 mm.	1·6 mm.	3·2 mm.	1·6 mm.	3·2 mm.
Length of sicula . .	—	—	—	2 mm.	2 mm.	1·6 mm.	2 mm.	2 mm.	1·5 mm.	2 mm.
No. of thecæ in 10 mm.	10—9	8	9—10	9—10	7	9—12	11—12	8—9	12—13	14—13
Inclination	30°—40°	45°	40°	45°	30°—35°	15°—20°	30°	45°	45°	40°—70°
Overlap	$\frac{1}{2}$—$\frac{2}{3}$	$\frac{3}{4}$	$\frac{7}{8}$—1	$\frac{2}{3}$—$\frac{3}{4}$	$\frac{2}{3}$	$\frac{2}{3}$—$\frac{1}{2}$	$\frac{1}{2}$—$\frac{2}{3}$	$\frac{2}{3}$—$\frac{3}{4}$	$\frac{2}{3}$	$\frac{7}{8}$—1

Genus **SCHIZOGRAPTUS**, *Nicholson*.

1876. *Schizograptus*, Nicholson, Geol. Mag., dec. 2, vol. iii, p. 248.

Polypary bilaterally symmetrical, consisting of four main uniserial stipes produced by dichotomous division from a primitive *Didymograptus* stage; these four main stipes are rigid, are spread out in a horizontal plane, and give off from one side only (thecal margins) simple lateral[1] branches at definite intervals.

Thecæ simple tubes expanding slightly in the direction of their apertures, usually in contact for a considerable fraction of their length.

The polypary is characterised by the possession of stipes of two (*dichotomous*) orders only, but from the stipes of the second order (main stipes) simple *lateral* branches are given off. Thus the *Schizograptus* polypary is, from this systematic point of view, of the *Tetragraptid* type; and may be theoretically regarded as a *Tetragraptus* of the *quadribrachiatus* type, in which the main stipes bear simple lateral branches. These lateral branches seem to originate, in all examples known, from the ventral or thecal margin of the main stipes. These main stipes increase

[1] Without entering upon the question as to the structural significance in the distinction between dichotomous and lateral (monopodial) types of branching, we here employ the term *dichotomous* when continuation of growth in the original direction would bisect the angle between the two stipes resulting from division, and *lateral* when the original stipe continues to grow in the same direction after division as before (Elles, 'Quart. Journ. Geol. Soc.,' 1898, p. 477; Ruedemann, 'Rep. of State Pal., New York State Museum,' 1902, p. 584).

very slightly in width from their origin, while the lateral branches appear to be of uniform breadth throughout their length. As a general rule the thecæ are obscure on the whole proximal portion.

Only two species of *Schizograptus* are at present known—*S. reticulatus* and *S. tardifurcatus.*

Schizograptus reticulatus (Nicholson). Plate VI, fig. 7.

1868. *Dichograpsus reticulatus*, Nicholson, Quart. Journ. Geol. Soc., vol. xxiv, p. 143, pl. v, figs. 4, 5.
1876. *Schizograptus reticulatus*, Nicholson, Geol. Mag., dec. 2, vol. iii, p. 248.
1898. *Schizograptus reticulatus*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 480.

Stipes rigid, those of first order short, those of second order about 4—7 cm. in length and 1·2 mm. in width, constituting the four main stipes of the polypary; from each of these, two lateral branches are early given off at a large angle (approximating to a right angle) with the axis of the main stipes, and all on the same side. Thecæ about ten in 10 mm., inclined at 20°, about 1 mm. in length, three times as long as wide; outer walls straight, overlapping one quarter of their length. Apertural margin straight, approximately perpendicular.

Description.—The first lateral branch is given off at a distance of about 5 mm. from the point of dichotomy, and the second at a distance of 10 mm. from the first. The distance between the two lateral branches is the same on all the main stipes. On one main stipe, whose total length was 70 mm., only two lateral branches are visible, and both of them arise within the first 17 mm. of its length. On no stipe have more than two lateral branches been observed, therefore it would seem likely that no more were developed.

The characters of the thecæ as given above are drawn up from several Lake District specimens more or less indifferently preserved, and must be regarded as essentially approximate.

Affinities.—*S. reticulatus* may readily be distinguished from the only other species yet known (*S. tardifurcatus*) by the short space between the point of dichotomy and the point of origin of the first lateral branch.

Horizon and Localities.—Arenig, Middle Skiddaw Slates (?).

Lake District: Scale Hill, Crummock; Barf.

Associates, etc.—*S. reticulatus* has as yet been only recognised in the Skiddaw Slates, where it is rare. Its associates are unknown. The best specimens are in Postlethwaite's collection.

Schizograptus tardifurcatus, Elles. Plate VI, fig. 8.

1898. *Schizograptus tardifurcatus*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 480, fig. 7.

Stipes rigid, those of first order short, those of second order 4—5 cm. in length and about 1 mm. in width, constituting the main stipes of the polypary; from each of these three lateral branches are given off at about 70°, all on the same side. Thecæ ten in 10 mm., inclined at about 20°, three times as long as wide; outer walls slightly curved, overlapping half their length. Apertural margins straight, oblique.

Description.—The first lateral branch is given off at a distance of 13 mm. from the point of dichotomy, the second at a distance of 8 mm. from the first, the third at a similar distance from the second, etc. Each theca has an average length of about 2 mm. In the type specimen (Pl. VI, fig. 8) a fourth branch appears to take origin from the opposite side to that of the other three, but this is due to an accident before preservation, as it may not even belong to the polypary.

Affinities.—This species differs from *S. reticulatus* in having more closely set lateral branches, and in these being situated further from the point of dichotomy.

Horizon and Locality.—Arenig, Middle Skiddaw Slates (?).

Lake District: Carlside Edge.

Associates.—*S. tardifurcatus* has not yet been recognised outside the Skiddaw Slates, where it is rare. The best specimens are in Postlethwaite's collection. Its associates are unknown.

Note.—In the year 1868 ('Quart. Journ. Geol. Soc.,' vol. xxiv, p. 144, pl. vi, figs. 4 and 5) Nicholson described and figured a fragmentary example of one of the main stipes of a compound Dichograptid, bearing numerous lateral branches on one side only. This fragment he named *Pleurograptus vagans*, believing it to be an example of a genus to which he had previously given the name of *Pleurograptus* ('Geol. Mag.,' 1867, vol. iv, p. 256).

With our present knowledge it is evident that the fragment referred to has no generic relationship to Nicholson's original *Pleurograptus*, which was founded on the Leptograptid species *Cladograptus linearis* of Carruthers. *P. vagans* belongs clearly to some Dichograptid genus, possibly *Schizograptus* or *Trochograptus*. We have given a figure of Nicholson's original specimen on Pl. VI, fig. 9; but the characters are so inadequate and poorly preserved that it is impossible to retain the name as that of a distinct species.

Genus **TROCHOGRAPTUS**, *Holm.*

1881. *Trochograptus*, Holm, Öfv. Kongl. Vet. Akad. Stockholm Förh., vol. xxxviii, No. 9, p. 49.

Polypary robust, typically bilaterally symmetrical, consisting of four main stipes, several centimetres in length, produced by dichotomous division from a primitive *Didymograptus* stage. From each of these four main stipes numerous compound lateral branches several centimetres in length are given off at irregular intervals.

Thecæ narrow tubes of the ordinary Dichograptid type.

The polypary is characterised by the possession of stipes of two orders only; but from the stipes of the second order (main stipes) compound lateral branches are given off. It may therefore be regarded as a *Tetragraptus* of the *quadribrachiatus* type, bearing compound lateral branches on its main stipes. It differs from *Schizograptus* in having compound instead of single lateral branches, and in having them disposed at irregular instead of regular intervals.

The Trochograpti often attain a very large size, and, as a general rule, there is no difference in the width of the main and lateral stipes. The distance between the lateral branches *increases* usually with remoteness from the sicula, and the angle at which they are given off usually *decreases* with the complexity of the branch; this is, however, not invariably the case. The thecæ are as a rule obscure on the main stipes, but can often be fairly well seen on some part of the lateral branches.

Only one species has as yet been described, viz. *T. diffusus*, Holm.

Trochograptus diffusus, Holm. Plates VII and VIII, figs. 1 *a*, *b*.

1881. *Trochograptus diffusus*, Holm, Öfv. Kongl. Vet. Akad. Stockholm Förh., vol. xxxviii, No. 9, p. 49, pl. xiii.

1898. *Trochograptus diffusus*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 479, pl. xxvii.

Main stipes and compound lateral branches curved, often several centimetres in length, robust, having an average width of 2 mm.; lateral branches always situated on same side of main stipe, and curved in the same direction; distance between lateral branches commonly increasing with remoteness from the sicula, while the angle of divergence decreases with the complexity of the stipe. Thecæ eleven in 10 mm., inclined 45°, average length 3 mm., six times as long as wide, outer wall straight, overlapping three quarters their length. Apertural margin concave, normal.

Description.—The lateral branching traced along one or other of the main stipes is seen to take place approximately at intervals of 25, 32, and 38 mm. respectively.

The angle at which the lateral branches come off varies from about 90° to 65°.

Fig. 43.—*Trochograptus diffusus*, Holm.

Distal thecæ on one of the lateral branches of specimen figured on Pl. VIII, fig. 1 *a*.

From the lateral branches additional lateral branches may be given off.

A small square disc with an average diameter of about 6·3 mm. commonly encloses the proximal parts of the main stipes, but this may be absent.

Affinities.—We have here referred the British examples of *Trochograptus* to the only species hitherto described, *i. e. T. diffusus*, Holm (*loc. cit.*); though they differ from it somewhat in having a more irregular mode of branching, and more thecæ in a given unit of length. *T. diffusus* resembles other compound Tetragraptids, such as *Schizog. reticulatus*, *S. tardifurcatus*, and *Holog. Deani*, in general plan of growth. The compound lateral branches, however, seem to distinguish it from any *Schizograptus*, while from *Holog. Deani* it may be separated by the fact that the lateral branches are all on the same side of the main stipe, while in *H. Deani* they are apparently given off at irregular intervals on both sides.

Horizon and Localities.—Arenig, Middle Skiddaw Slates.

Lake District: Scaw Gill; New Brow Quarry, Upper Lorton; Whit Beck, Upper Lorton; Grisedale Pike.

Associates, etc.—*T. diffusus* is only known in Britain from the Skiddaw Slates, where large specimens occur at certain horizons in some abundance. Its associates are not known.

There are good specimens in the collections of the Keswick Museum and the Woodwardian Museum.

Genus **HOLOGRAPTUS**, *Holm.*

1881. *Holograptus*, Holm, "Tvenne nya slägten af familjen Dichograptidæ," Öfv. Kongl. Vet. Akad. Stockholm Förh., vol. xxxviii, No. 9, p. 45.

1893. *Rouvilligraptus*, Barrois, Ann. d. l. Soc. Géol. du Nord, pl. xxi, p. 107.

Polypary robust, typically bilaterally symmetrical, consisting of four main stipes many centimetres in length, produced by dichotomous division from a primitive *Didymograptus* stage. From both sides of each of these four main stipes many lateral branches, several centimetres in length, are given off at subregular intervals; some of these lateral branches are simple, others compound.

Thecæ narrow tubes of the Dichograptid type.

The form of the polypary in *Holograptus* is closely related to that of *Trochograptus*, differing, so far as is known, only in the fact that the four main stipes (stipes of the second order) apparently throw off lateral branches from both sides. These lateral branches may be either simple or compound.

While at first sight there seems to be no doubt that the lateral branches are given off from both sides of the four main stipes, yet it is impossible to prove that this was the *original* mode of growth. An examination of the left-hand branch drawn on fig. 2 *a*, Pl. VIII, seems to lend some support to the suggestion that the lateral branches may have really originated from one side only (thecal margin). If this should prove to be invariably the case, then *Trochograptus* and *Holograptus* could no longer be regarded as separate genera. Whether this be so or not, there seems to be no doubt that the genus *Rouvilligraptus* of Barrois is identical with the *Holograptus* of Holm.

The Holograpti attain an extraordinary size, exceeding that of any other Graptolite genus with the exception of *Temnograptus*. Our British examples must have been, when fully grown, more than 80 cm. in length; and the branches, if disposed regularly and spread out symmetrically, must have extended over a circular area of that diameter. There appears to be no difference in the width of the stipes of the first and second order, or of the lateral branches. The distance between the points of origin of the lateral branches on the four main stipes is large near the sicula, and appears to *decrease* irregularly towards the distal extremity, where the lateral branches are approximate and numerous. A few of these lateral branches show a tendency to re-branch in their turn, but none are known to possess more than two terminal branches.

The form of the thecæ is, as a rule, obscure.

Holograptus Deani, Lapworth, MS. Plate VIII, figs. 2 *a*—*c*.

Main stipes and compound lateral branches somewhat curved; main stipes about 40 cm. in length, robust and having an average width of 2 mm. Lateral branches arising from both sides of the four main stipes and curved in the same direction, usually at an angle of about 60°. Distance between the lateral branches decreasing with remoteness from sicula, as does also the angle of divergence. Compound lateral branches short, rare. Thecæ of the ordinary Dichograptid type, nine in 10 mm., angle of inclination 35°—45°, average length about 2·5 mm.

Description.—The distance between the points of origin of the lateral branches on the main stipes decreases, as a rule, from an average of about 6 cm. near the sicula to about 1 cm. near the distal ends. A larger proportion of lateral branches

is given off from the outer curve of the main stipes than from the inner, and it is usually impossible to say on which side a branch arose originally.

As a rule, little more is preserved than the general outline of the branches, the apertures of the thecæ being usually embedded in the rock. A true profile view is rarely seen, so that the characters of the thecæ cannot all be made out.

Affinities.—The British example of *Holograptus* figured above, which is distinguished as *Holograptus Deani* in Lapworth's collection, closely resembles *Rouvilligraptus* (*Holograptus*) *Richardsoni* of Barrois (*loc. cit. supra*) in general appearance. It differs, however, in the fact that the thecæ are more closely set (nine as against seven to eight in 10 mm.), and the point of origin of the first of the lateral branches is more than twice as distant as in the French form. Too little is known of Hall's original species, *G. Richardsoni* ('Grapt. of the Quebec Group,' 1865, p. 107, pl. xii, figs. 1, 8), to be certain of its specific identity or otherwise. *Holograptus Deani* appears to differ from *H. expansus*, Holm, in mode of branching, and in the more closely set thecæ (nine as against seven to seven and a half in 10 mm.). The American, Swedish, and British examples are all, however, closely related to each other, and although at present they are separated as distinct forms, it is not impossible that they are variants of one and the same widely distributed species.

Horizon and Locality.—Arenig, Skiddaw Slates.

Lake District: Newlands, near Buttermere.

Associates.—*Holograptus Deani* occurs in the Skiddaw Slates associated with *Tetrag. quadribrachiatus*, *Didymog. v-fractus*, and *D. Nicholsoni*.

The only specimen is in Lapworth's collection, and is called after its discoverer, the late Dr. Deane, of Birmingham.

Genus **DICHOGRAPTUS**, *Salter* (*pars*).

1863. *Dichograpsus*, Salter (*pars*), "Note on the Skiddaw Slate Fossils," Quart. Journ. Geol. Soc. vol. xix, p. 137.

Polypary typically bilaterally symmetrical, consisting of eight long uniserial main stipes, which are produced by repeated dichotomous division through *Didymograptus* and *Tetragraptus* stages.

Thecæ simple, cylindrical or subcylindrical tubes, inclination and overlap varied.

The polypary is characterised by the possession of stipes of three orders only. It would seem to have originated on lines similar to those indicated for *Tetragraptus;* but in this case in addition to the primary *Didymograptus* stage (stipes of first order), which is short-lived, there is superadded a secondary *Tetragraptus* stage

(stipes of second order), which is also of short duration. Each of the four stipes thus formed is again dichotomously divided, with the result that eight stipes (stipes of third order) are ultimately produced. These undergo no further division, and persist as the eight main stipes of the polypary.

It is a matter for regret that the specimens from the Skiddaw Slates, the only beds in Britain in which this genus is abundantly represented, are, as a whole, so poorly preserved. It is often impossible to make out any details concerning the thecæ, since the stipes are preserved with their dorsal surfaces uppermost, and with the thecæ embedded in the rock. This is almost invariably the case with the thecæ on the stipes of the first and second order; those on the stipes of the third order (main stipes) are, however, often more or less clearly seen.

It seems most probable that the main stipes of the Dichograpti grew in one and the same horizontal plane. All the forms at present known fall naturally into one horizontal series, which contains two groups.

Horizontal Series.—Group I. Type *D. octobrachiatus.*
D. octobrachiatus,
var. *Sedgwickii.*
Group II. Type *D. separatus.*
D. separatus.

HORIZONTAL SERIES.

Dichograpti in which the main stipes are straight or curved, and which grow in one horizontal plane.

Group I.—Type *D. octobrachiatus.*

Dichograpti with robust stipes, having thecæ which overlap for a considerable portion of their length.

Dichograptus octobrachiatus (Hall). Plates IX and X, figs. 1 *a*—*e*.

1858. *Graptolithus octobrachiatus* (Hall), Geol. Survey Canada Rep., 1857, p. 122.
1863. *Dichograpsus aranea* (Salter), Quart. Journ. Geol. Soc., vol. xix, p. 137, figs. 9 and 10.
1865. *Graptolithus octobrachiatus* (Hall), "Grapt. of Quebec Group," Geol. Survey Canada, dec. 2, p. 96, pl. vii, figs. 1—7, and pl. viii, figs. 1—4.
1868. *Dichograpsus octobrachiatus*, Nicholson, Quart. Journ. Geol. Soc., vol. xxiv, p. 129, pl. v, figs. 1 and 2.
1898. *Dichograptus octobrachiatus*, Elles (*pars*), Quart. Journ. Geol. Soc., vol. liv, p. 483.

Stipes of first and second orders very short; main stipes of the third order typically straight and rigid, often several centimetres in length, slender at origin, but widening quickly to a maximum breadth of 3·2 mm. Thecæ five to ten in 10 mm., inclined 20°—55°; outer walls slightly curved, four times as long as wide, in contact one half to one third their length; apertural margins concave, normal.

Description.—The stipes of the first order are about 1 mm. in length, those of the second order slightly longer—1·6 mm., while those of the third order may attain a length of from 12 to 15 cm. Many young examples of this species barely attain 2·5 cm. in length, and the stipes are relatively narrower. The main stipes, while typically straight, are often preserved showing a certain amount of curvature.

It is only on the main stipes that any details regarding the thecæ can be determined, though these are undoubtedly present on the stipes of both first and second orders. The thecæ on the main stipes make an angle of about 20° with the axis of the stipe at their bases, but these curve so decidedly that the inclination rises to 55° near their apertures. The thecæ when mature have an average length of 3—4 mm., but in smaller forms they are much shorter.

The whole proximal part of the polypary is frequently enveloped in a membranous disc, which varies greatly in size in different individuals. This disc, however, may be altogether wanting.

Remarks.—*Dichograptus octobrachiatus*, although typically eight-stiped, exhibits great variation in the number of its stipes. The typical form, having eight stipes of the third order, appears to be the commonest, and from this form the species derives its name. But individuals, agreeing in all respects except in the number of stipes, have seven, six, or five stipes, and there is no reason for doubting that they all belong to one and the same species. In the normal type with eight stipes of the third order there are four short stipes of the second order, and two short stipes of the first order; both stipes of the first order and all four of the second order undergo dichotomous division.

In the form with seven terminal stipes (septad type) both stipes of the first order divide dichotomously, but one of the stipes of the second order fails to do this, and persists as a single stipe, the other three dividing as in the normal form. In the form with six terminal stipes (hexad type) two of the stipes of the second order show no dichotomous division, and in the pentad type (five stipes) only one stipe out of four divides dichotomously. These variations of *Dichograptus octobrachiatus* are best regarded as *aborted* specimens of the typical octad form.

Total failure of dichotomy in the stipes of the second order would obviously result in the production of a *Tetragraptus* of the *quadribrachiatus* type.

Affinities.—*D. octobrachiatus* (including var. *Sedgwickii*) may readily be distinguished from the only other species of *Dichograptus* as yet recorded, *D. separatus*,

by the smaller size of its stipes of the first order, and the greater width of its main stipes.

Horizon and Localities.—Arenig, Middle Skiddaw Slates (*Dichograptus* beds).

Lake District: Randal Crag, Skiddaw; Mire House, Skiddaw; Carlside Edge, Slape Crags above Hope Hill, Brackenthwaite; Outerside; Grisedale Pike. *S. Scotland:* Bennane Head, Ballantrae.

Associates, etc.—*D. octobrachiatus* occurs in abundance in the Middle Skiddaw Slates of the Lake District associated with *Didymograptus hirundo*, *D. nitidus*, *D. gibberulus*, *D. v-fractus*, *Tetragraptus*, sp. (?), and *Loganograptus Logani* (nonad type). Numerous good specimens are in the collections of the British Museum (Nat. Hist.), the Keswick Museum, the Woodwardian Museum, and the private collections of Lapworth, Postlethwaite, and Christopherson.

Var. **Sedgwickii**, Salter. Plate X, figs. 3 *a*, *b*.

1863. *Dichograpsus Sedgwickii*, Salter, Quart. Journ. Geol. Soc., vol. xix, p. 137, fig. 11.

In addition to the typical *D. octobrachiatus* there occurs in the Skiddaw Slates a form which, while agreeing with *D. octobrachiatus* in the mode of branching and in the number of thecæ to the inch, has a decidedly less rigid habit, the stipes being narrower and distinctly flexuous. The thecæ, too, are proportionately shorter.

Fig. 44.—*Dichograptus octobrachiatus*, var. *Sedgwickii*, Salter.

Distal thecæ. Enlargement of Pl. IX, fig. 3 *a*.

This is the form described by Salter as a distinct species under the title *D. Sedgwickii*, but it appears to us to be better regarded as a variety of *D. octobrachiatus*.

Horizon and Locality.—Arenig, Middle Skiddaw Slates.

Lake District: Braithwaite.

Associates, etc.—The associates of this variety are unknown. The best specimens known to us are in the collection of the Geological Survey at Jermyn Street, and in Postlethwaite's collection.

Group II.—Type *D. separatus*.

Dichograpti with slender stipes, having thecæ which overlap for a small fraction of their length.

Dichograptus separatus, Elles. Plate X, figs. 4 *a*, *b*.

1898. *Dichograptus separatus*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 484, fig. 10.

Stipes of first order either equalling in length, or longer than, those of second, but both short compared with length attained by main stipes of third order; these last are slender and somewhat rigid, 2·5 to 7·5 cm. in length, but never exceed ·5 mm. in width. Thecæ ten to twelve in 10 mm., narrow tubes, outer walls three times as long as wide, inclined 20°, and overlapping about one third their length. Apertural margins straight, perpendicular.

Fig. 45.—*Dichograptus separatus*, Elles.

Distal thecæ, indifferently preserved. Enlargement of Pl. X, fig. 4 *a*.

Description.—The stipes in this form are very narrow and rigid; those of the first order are longer than those of other species of the same genus. Each of the stipes of the first order is fully 3 mm. in length, and thus what the earlier authors would have regarded as the "funicle" is about 6 mm. long. The stipes of the second order are about 3 mm. in length or rather less, and the pairs of this order include an angle of about 105°, while the pairs of stipes of the third order include an angle of about 70°.

The thecæ are very indifferently preserved, and details are obscure.

Affinities.—This species is easily recognised by its small width and its long stipes of the first order, which serve to distinguish it from *D. octobrachiatus*, the only other species at present recognised.

Horizon and Locality.—Arenig, Middle Skiddaw Slates.

Lake District: Outerside.

Associates, etc.—Only two complete specimens of *D. separatus* are known, both of which are in the Woodwardian Museum. The species occurs associated with fragments of other Dichograptidæ in the Middle Skiddaw Slates of Outerside.

Genus **LOGANOGRAPTUS**, *Hall.*

1868. *Loganograptus*, Hall, "Introduction to Study of Graptolitidæ," N. Y. State Cab. Nat. Hist., 20th Ann. Rep., p. 226.

Polypary typically bilaterally symmetrical, consisting of sixteen main uniserial stipes, which are produced by repeated dichotomous division through *Didymograptus*, *Tetragraptus*, and *Dichograptus* stages.

Thecæ simple, overlapping tubes.

The polypary is very similar in its mode of development to *Dichograptus*, but possesses capacity for still greater dichotomy; and hence, while *Dichograptus* is characterised by the possession of stipes of three orders only, *Loganograptus* has stipes of four orders. Thus, in addition to the short *Didymograptus* and *Tetragraptus* stages, there is a short-lived *Dichograptus* stage, each stipe of which quickly undergoes dichotomous division, resulting in the formation of the sixteen main stipes of the *Loganograptus* polypary.

It is not the actual number of stipes, but the degree of capacity for dichotomy which is the essential characteristic of the genus; thus specimens having seven or six stipes may be true Loganograpti, but there cannot be fewer stipes than six. A typical *Loganograptus* has sixteen stipes, all of the fourth order; but there may be, and often is, considerable atrophy. Examples are known showing this in various degrees, such as twelve-stiped, ten-stiped, seven-stiped, etc.; but, so far as known, the series is not quite complete. In a seven-stiped *Loganograptus* all the stipes of the second order are developed, but only two undergo further division, so that only four stipes of the third order are produced; of these only one undergoes further division. The number of stipes is therefore made up as follows:

$$2^2 + 3^3 + 2^4 = 7$$

Similarly, in a six-stiped form, three out of the four stipes of the second order persist as single stipes; the fourth divides dichotomously, giving rise to two stipes of the third order, one of which persists, and the other is dichotomously divided, the formula being—

$$3^2 + 1^3 + 2^4 = 6$$

All the forms of *Loganograptus* at present known seem to be referable to a single species, *L. Logani*, although there is great variation in the apparent width of the stipes, due to the cleavage of the beds and to the method of preservation.

Loganograptus Logani, Hall. Plate XI, figs. 1 *a—g*.

1858. *Graptolithus Logani*, Hall, Geol. Survey Canada Rep., 1857, p. 115.
1859. *Graptolithus Logani*, Hall, Pal. N. Y., vol. iii, p. 502, figs. 1—3.
1865. *Graptolithus Logani*, Hall, "Grapt. of Quebec Group," Geol. Survey Canada, dec. 2, p. 100, pl. ix, figs. 1—9.
1868. *Loganograptus Logani*, Hall, "Introduction to Study of Graptolitidæ," N. Y. State Cab. Nat. Hist., 20th Ann. Rep., p. 226.
1868. *Dichograpsus Logani*, Nicholson, Quart. Journ. Geol. Soc., vol. xxiv, p. 128.
1898. *Loganograptus Logani*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 476.

Stipes of first, second, and third orders very short; main stipes of the fourth order 5 cm. or more in length, somewhat flexuous, narrow at their origin, but widening to a maximum of about 1·6 mm. Thecæ eight to nine in

10 mm., outer wall slightly curved, inclined 35°, about four times as long as wide, and overlapping half their length. Apertural margin straight or very slightly curved, perpendicular.

The stipes of the first three orders are all very short, but they increase in length with remoteness from the sicula; thus the stipes of the first order average 1 mm. in length, those of the second order 1·6 mm., and those of the third order 2·1 mm.; dichotomy is therefore complete within 5 mm. from the point of origin of the stipes.

The details of the thecæ are often obscure and hard to determine, but when the stipes are fully developed they seem to have an average length of nearly 3 mm.

A disc is frequently present, as in *Dichog. octobrachiatus.*

Horizon and Localities.—Arenig, Middle Skiddaw Slates.

Lake District: Outerside; Barf; Randal Crag, Skiddaw.

Associates, etc.—Up to the present time this species has only been recorded in Britain from the Skiddaw Slates of the Lake District, where poorly preserved specimens are fairly abundant. Many fair examples are in the collection of the British Museum, the Woodwardian Museum, and the Keswick Museum. The best specimens come from Outerside.

Genus **CLONOGRAPTUS**, *Hall.*

1873. *Clonograpsus,* Hall, compare Nicholson, Ann. Mag. Nat. Hist., ser. 4, vol. xi, p. 138.

Polypary bilaterally symmetrical, typically possessing at least thirty-two slender uniserial terminal stipes, produced by repeated dichotomous division through *Didymograptus, Tetragraptus, Dichograptus,* and *Loganograptus* stages.

Thecæ simple overlapping tubes.

The *Clonograptus* polypary is characterised by the possession of stipes of at least five orders. Its nearest allies appear to be *Loganograptus* and *Dichograptus.* In *Loganograptus* stipes of more than four orders do not exist, while in *Dichograptus* there are three orders only; all the earlier stages are short-lived, and nearly equal in length. In *Clonograptus,* dichotomy is carried one or several more stages beyond the *Loganograptus* stage (2^4), so that examples are known having stipes of the sixth order (2^6). Again, the distance separating the successive dichotomous divisions increases gradually and fairly uniformly from the sicula outwards. It is probable that dichotomy was carried farther still, and that stipes of the seventh and eighth orders would be found in larger specimens; it is therefore impossible to regard any of the terminal stipes as the *main* stipes.

The thecæ are often well preserved, and are generally visible on the stipes of the third, fourth, and following orders, though they are not well seen on the stipes of the earlier stages.

As in other many-branched forms, considerable atrophy frequently takes place; thus, for example, in a typical *Clonograptus* all thirty-two stipes should belong to the fifth order:

$$8^5 + 8^5 + 8^5 + 8^5 = 32.$$

But we may have forms in which the number is only seventeen, which is made up as follows:

$$6^5 + 9^4 + 2^3 = 17;$$

and other aborted examples are known.

Here, again, as in *Dichograptus*, it is not the *number of stipes* which is the essential characteristic of the genus, but the degree of capacity for dichotomy.

The only species that occurs in Britain in a sufficiently satisfactory state for specific description is *C. tenellus*, with its variety *C. Callavei*. In these British specimens the type of thecæ is markedly similar to that characteristic of certain *Dictyonema*. The American examples of *Clonograptus*, however, originally figured by Hall, present the ordinary type of cell seen in other Dichograptids.

Clonograptus tenellus (Linnarsson). Plate XI, figs. 2 *a*—*c*.

1871. *Dichograptus tenellus*, Linnarsson, Öfv. Kongl. Vet. Akad. Förh. Stockholm, vol. xxviii, No. 6, p. 795.

1876. *Dichograptus tenellus*, Linnarsson, Geol. Mag., dec. 2, vol. iii, p. 242.

1876. *Trichograptus tenellus*, Nicholson, Geol. Mag., dec. 2, vol. iii, p. 248.

1880. *Dichograptus tenellus*, Linnarsson, Geol. Fören. Förhandl., vol. v, p. 132.

1882. *Dichograptus* (?) *tenellus*, Brögger, Die Sil. Etagen 2 u. 3, p. 37.

1885. *Clonograptus tenellus*, Herrmann, Die Graptolitenfam. Dichograptidæ, p. 96.

1892. *Clonograptus tenellus*, Moberg, Geol. Fören. Förhandl., vol. xiv, p. 89, pl. ii, figs. 1—3.

1898. *Clonograptus tenellus*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 474.

Stipes somewhat rigid, very slender and thread-like, never exceeding ·5 mm. in width even at the apertures of the thecæ. Thecæ nine to ten in 10 mm., slender tubes, widening slightly toward their apertures, inclined 20°, overlapping for the merest fraction of their length; outer walls slightly curved, three times as long as wide. Apertural margins concave, oblique, conspicuously mucronate.

Description.—Only a few specimens of *C. tenellus* have as yet been found in Britain, but these are, as a rule, very well preserved. *C. tenellus* is characterised by its extreme tenuity and by the mucronate thecal apertures, which recall strongly those characteristic of many *Dictyonemas* (*D. cervicorne*). This last character is,

however, only visible on the best preserved specimens, or on the more distal stipes when these are seen in true profile. Each theca averages 1·5 mm. in length.

Fig. 46.—*Clonograptus tenellus*, Linnarsson.

Distal thecæ in low relief. Mary Dingle, Shineton Shales. Coll. H.M. Geological Survey.

Affinities.—The peculiar character of the distal thecæ in the Shropshire specimens (see Fig. 46) is not clearly brought out in the figures of the Swedish examples of *C. tenellus* (*loc. cit. supra*); but as these features are seldom seen, being dependent on the mode of preservation, and the Swedish and British forms are identical in other respects, we have no hesitation in referring them to the same species. The example figured on Pl. X, fig. 2 *c*, from Barf, has been referred to *C. tenellus* with doubt.

Horizon and Localities.—Tremadoc. Lower Skiddaw Slates.

N. Wales: Tremadoc (?). *Shropshire:* Mary Dingle; Conrad Brook (?). *Lake District:* Barf (?).

Associates, etc.—*C. tenellus* occurs in Shropshire associated with *C.*, var. *Callavei.* It is one of the earliest Graptolites known to us. It also doubtfully occurs in the Lower Skiddaw Slates of Barf, and in the Tremadoc beds of Wales. Good specimens of the typical form are in the collection of H.M. Geological Survey.

Var. **Callavei** (Lapworth). Plate XI, figs. 3 *a*—*c*.

1880. ? *Bryograptus Callavei*, Lapworth, Ann. Mag. Nat. Hist. [5], vol. v, p. 165, pl. v, fig. 21.

Description.—In addition to the typical form of *Clonograptus tenellus*, there occur associated with it in the Shineton Shales examples of a variety, the branches of which are more rigid and much wider. The thecæ are of the same type, but larger and fewer in a given unit of length (eight in 10 mm.). Each theca has an average length of 2 mm. Figs. 3 *a* and 3 *b*, Pl. XII, show the true characteristics of this variety.

Fig. 47.—*Clonograptus Callavei*, Lapworth.

Distal thecæ in low relief. Enlargement of Pl. XI, fig. 3 *a*.

Remarks. — The specimen originally described and figured by Lapworth as *Bryograptus Callavei* from Mary Dingle, Shineton Shales, has unfortunately been lost. There occur, however, at the same locality abundant examples of the special variety of *Clonograptus tenellus* here referred to. These agree fully in the number and form of the thecæ with Lapworth's description, and there can be little or no doubt that his

original (*Bryograptus Callavei*) was a specimen of this variety. In favour of this view may also be cited the fact that in Dr. Callaway's collection there is a specimen of this variety which is labelled *Bryograptus Callavei.* In future, therefore, the form hitherto cited as *Bryograptus Callavei* should be referred to *Clonograptus tenellus*, var. *Callavei.*

Horizon and Localities.—Tremadoc. Shineton Shales.

Shropshire: Mary Dingle; Garmston.

Associates, etc.—Var. *Callavei* has up to the present time been only recorded from the Shineton Shales of Shropshire, where it occurs associated with *C. tenellus.*

The best preserved specimens are in the collection of H.M. Geological Survey.

Note.—On many slabs of Skiddaw Slate there may be observed several dichotomously divided stipes of what may be a species of *Clonograptus,* though in their fragmentary condition specific determination is not advisable. For the most part they appear to be the terminal stipes; they are slender, flexed, and rather delicate, and have a maximum width of about 1 mm. The thecæ are very clearly seen; they are long, narrow tubes of uniform width, numbering eight in 10 mm.; they overlap one third their length, and have straight perpendicular apertures.

There are also fragments of some rather more robust stipes in which the thecæ are about ten in 10 mm., and overlap half their length.

Genus **TEMNOGRAPTUS**, *Nicholson.*

1876. *Temnograptus,* Nicholson, Geol. Mag., dec. 2, vol. iii, p. 248.

Polypary robust, bilaterally symmetrical, consisting of an indefinite series of stipes (at least of seven orders), produced as the result of repeated dichotomous division from primitive *Didymograptus-Clonograptus* stages. Stipes of two earliest stages short; all those subsequently formed of equal length.

Thecæ simple narrow tubes, overlapping for a small portion of their length.

This genus *Temnograptus* is characterised by the possession of stipes of at least seven orders. It is closely related to *Clonograptus,* but seems to possess greater capacity for dichotomy; and in addition, while in *Clonograptus* the three earliest stages are comparatively short-lived, and the succeeding ones progressively longer, in *Temnograptus* the *Didymograptus* and *Tetragraptus* stages only are short, and all the subsequent ones are of equal duration. This implies that after dichotomy has taken place twice subregularly (2^2), it then occurs at regular intervals. The polypary of *Temnograptus* is also far larger and more robust than that of *Clonograptus.*

The only species belonging to this genus at present known in Britain is *T. multiplex*.

Temnograptus multiplex (Nicholson). Plate XII, fig. 1.

1868. *Dichograpsus multiplex*, Nicholson, Quart. Journ. Geol. Soc., vol. xxiv, p. 129, pl. vi, figs. 1—3

1876. *Temnograptus multiplex*, Nicholson, Geol. Mag., dec 2, vol. iii, p. 248.

1898. *Temnograptus multiplex*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 477, fig. 6.

Stipes very slightly curved and of an approximately uniform width of 2 mm.; stipes of first order short, those of second order somewhat longer, while all stipes subsequently formed are about 2·7 cm. in length. Angle of divergence decreasing with remoteness from the sicula. Thecæ nine in 10 mm., inclined 30°; average length 2 mm., three to four times as long as wide; outer wall slightly curved; overlapping one third their length. Apertural margin concave, normal.

Description.—The stipes of the first order (*Didymograptus* stage) are short, not exceeding 4 mm. in length; those of the second order (*Tetragraptus* stage) have a length of about 8·5 mm.; while those of the third, fourth, fifth, sixth, and seventh orders have a length of 2·7 cm. The angle of divergence between the stipes appears to diminish steadily as it gets further away from the proximal end, and thus between the two stipes of order 2 the angle is about 90°; between those of order 3, 75°; between those of order 4, about 70°; between those of order 5, 50°; between those of order 6, about 40°.

Fig. 48.—*Temnograptus multiplex*, Nicholson.

Distal thecæ. Enlargement of part of Pl. XII, fig. 1.

Nicholson gives the number of thecæ as six in 10 mm. (sixteen to inch), but as many as nine in 10 mm. can be counted on some of the distal stipes.

Affinities.—*T. multiplex* resembles at first sight the compound Dichograpti (*Holog Deani* and *Trochog. diffusus*); it should, however, be readily separated from these by the character of its branching, which is dichotomous throughout. It resembles the Clonograpti in its branching, but is more robust and possesses greater capacity for dichotomy.

Horizon and Locality.—Arenig, Middle Skiddaw Slates. *Lake District:* Peelwyke, Bassenthwaite.

Associates, etc.—*T. multiplex* has been recorded from the Skiddaw Slates of the Lake District only. Its associates are unknown. The two type specimens are in Christopherson's collection, and are on the same slab; the reverse of one of these is in the Woodwardian Museum, the reverse of the other in the collection of the Geological Survey at Jermyn Street.

Genus **BRYOGRAPTUS,** *Lapworth.*

1880. *Bryograptus,* Lapworth, Ann. Mag. Nat. Hist. [5], vol. v, p. 164, pl. v, fig. 22.

Polypary bilaterally subsymmetrical, consisting of two compound main stipes diverging at a small angle from a well-marked sicula, and originating similar compound or simple stipes either by dichotomous or lateral division.

Thecæ small, of the *Dichograptus* type, cylindrical or subcylindrical tubes of varying inclination, overlapping for a considerable fraction of their length.

FIGS. 49 *a* and *b*.—*Bryograptus Kjerulfi,* Lapworth.

a. b

a. Obverse view, showing growth-lines on sicula.
b. Reverse view, showing crossing canal. Both specimens on same slab. Figured Elles, 'Quart. Journ. Geol. Soc.,' vol. liv, p. 472, fig. 5. Barf, Skiddaw Slates. Coll. W. A. Brend.

The initial stages of the *Bryograptus* polypary are in all respects comparable with those of *Didymograptus*, the difference being that in the former after a longer or shorter period of growth the stipes of the first order (*Didymograptus* stage) give off lateral branches from their thecal margins. These lateral branches may be simple or compound. There is great variability within the limits of the genus in the number of stipes ultimately developed, and also in the type of the branching.

The British Bryograpti fall into two natural serial groups according to the direction of growth of their main stipes; thus we have

(1) **Dependent Series.**—GROUP I. Type *B. Kjerulfi.*
B. Kjerulfi,
var. *cumbrensis.*

(2) **Deflexed Series.**—GROUP II. Type *B. divergens.*
B. divergens.

These groups may theoretically be regarded as including branched Didymograpti of the *indentus* and *deflexus* types respectively.

DEPENDENT SERIES.

Bryograpti in which the main stipes diverge downward, and tend to become approximately parallel.

Group I.—Type *Br. Kjerulfi.*

Bryograpti in which the main stipes are straight, slender, and of uniform width; the thecæ are fairly numerous, inclined at low angles, and free for the greater part of their length.

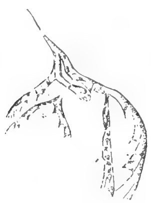
Bryograptus Kjerulfi, Lapworth. Plate XII, figs. 3 *a*, *b*.

1880. *Bryograptus Kjerulfi*, Lapworth, Ann. Mag. Nat. Hist. [5], vol. v, p. 164, pl. v, fig. 22.
1882. *Bryograptus Kjerulfi*, Brögger, Die Silur.-Etagen, 2 u. 3, p. 37, pl. xii, fig. 20 *a*.
1898. *Bryograptus Kjerulfi*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 469, fig. 1.

Main stipes short, 1·2 to 2 cm. in length, and not exceeding 1 mm. in width; diverging from a conspicuous sicula at a small angle, and growing subvertically downward; from their inner or thecal margins originate two or more symmetrically disposed compound lateral branches. Thecæ eight to nine in 10 mm., inclined 20°, having an average length of 1·5 mm., four times as long as wide, inclining slightly in the direction of their apertures, overlapping one third their length, and having their outer walls slightly curved. Apertural margins concave.

Description.—The polypary is always short; Lapworth gives the angle of divergence of the main stipes as 40°, but it often appears larger owing to the mode of preservation. The lateral branches are symmetrically disposed,—that is to say, they are given off at similar distances on either side of the main stipes.

FIG. 50.—*Bryograptus Kjerulfi*, Lapworth.



Proximal end, showing frequent branching; obverse view. Figured Elles, 'Quart. Journ. Geol. Soc.,' vol. liv, p. 470, fig. 1. Barf, Skiddaw Slates. On same slab as Figs. 49 *a* and *b*.

The sicula has a length of 1·6 mm., and from its apex a fine thread-like prolongation (the nema or virgula) is often seen to extend.

Affinities.—*Br. Kjerulfi* is characterised by its shrub-like form, and by the fact that the main stipes have a tendency to run parallel to each other in a manner which forcibly suggests the habit of the later "*tuning-fork*" Graptolites.

It resembles its variety *cumbrensis* in the general shape and characters of the thecæ, but differs in the symmetrical disposition of its lateral branches. From *Br. divergens* it differs in the direction of growth of the main stipes, and from *Br. ramosus*, Brögger, in the number of thecæ in a given unit of length.

Horizon and Localities.—Tremadoc? Lower Skiddaw Slates (*Bryograptus* beds). *Lake District:* Barf.

Associates, etc.—*Br. Kjerulfi* occurs in the Lower Skiddaw Slates of the Lake District associated with var. *cumbrensis*. The species has a gregarious habit, as may be seen from the slab figured on Pl. XII, fig. 3 *b*.

The best specimens known to us are in the collections of the Jermyn Street Museum, Postlethwaite, and Mr. W. A. Brend.

Var. **cumbrensis** (Elles). Plate XII, figs. 4 *a*–*c*.

1894. *Bryograptus ramosus*, Marr, Geol. Mag., p. 130, figs. 1–5.
1898. *Bryograptus ramosus*, var. *cumbrensis*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 471, figs. 3 and 4.

In addition to the typical species of *Br. Kjerulfi*, there occur in the Skiddaw Slates in association with it equally abundant specimens of a form which differs from *Br. Kjerulfi* in the unsymmetrical disposition of its lateral branches, and it seems advisable to separate this as a distinct variety.

FIG. 51.—*Bryograptus Kjerulfi*, var. *cumbrensis*, Elles.

Proximal end, showing sicula and long nema. Enlargement of Pl. XII, fig. 4 *a*.

These specimens were originally referred by Marr (*loc. cit. supra*) to the *Br. ramosus* of Brögger, which they resemble in the general arrangement of the stipes. It appears, however, certain that Brögger's species is characterised by far more closely set thecæ, hence this form was separated later and regarded as a variety of Brögger's *Br. ramosus*. It is probable, however, that there is great variation in the branching of all Bryograpti, and that no one definite plan is followed even within the limits of a single species. Since, therefore, the forms here separated as var. *cumbrensis* agree very closely with *Br. Kjerulfi* in the characters of their thecæ, and differ only in the possession of unsymmetrically disposed lateral branches, we prefer to regard them as a variety of that species.

Horizon and Locality.—Tremadoc. Lower Skiddaw Slates (*Bryograptus* beds).

Lake District : Barf.

Associates.—Var. *cumbrensis* occurs in the Lower Skiddaw Slates associated with *Br. Kjerulfi*, and also occasionally with *T. Bigsbyi*. The best specimens are in the Woodwardian Museum and Postlethwaite's collection.

DEFLEXED SERIES.

Bryograpti with flexed main stipes diverging downward, the initial angle of divergence being less than 180°.

Group II.—Type *Br. divergens*.

Bryograpti in which the main stipes are flexed and slender, and from their thecal margins lateral branches are given off at irregular intervals. Thecæ numerous, inclined at low angles, free for the greater part of their length.

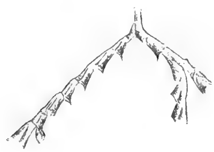
Bryograptus divergens, sp. nov. Plate XII, fig. 2.

1894. *? Bryograptus Callavei*, Marr, Geol. Mag., p. 130, fig. 6.
1898. *Bryograptus*, cf. *Callavei*, Elles, Quart. Journ. Geol. Soc , vol. liv, p. 470, fig. 2.

Main stipes 1·4 cm. in length, flexed, slender, not exceeding ·6 mm. in width, diverging from the sicula at about 90°; from their inner thecal margins unsymmetrically disposed lateral branches are given off. Thecæ twelve to thirteen in 10 mm., inclined 20°, overlapping one third to one half their length, having an average length of 1·5 mm.; five times as long as wide, of uniform breadth, and with outer walls slightly curved. Apertural margins straight, oblique, with mucronate denticle.

Description.—Unfortunately one specimen only of this species is known, and that shows merely two incomplete lateral branches arising at different levels on each of the main stipes.

Fig. 52.—*Bryograptus divergens*, sp. nov.



Proximal end, obverse view. Enlargement of Pl. XII, fig. 2.

The sicula is incomplete, but must have been at least 1·2 mm. in length.

Remarks.—This species was at first regarded as a possible variety of Lapworth's *Br. Callavei.* Since that form is now known not to be a *Bryograptus* (see p. 84), it is necessary to give this specimen a new name. *B. divergens* differs from other British Bryograpti in the wider divergence of the main stipes.

Horizon and Locality.—Tremadoc (?). Lower Skiddaw Slates.

Lake District: Barf.

Associates, etc.—The solitary specimen of *Br. divergens* at present known is in the Woodwardian Museum. It was found in the Skiddaw Slates, but its associates are unknown.

Genus **TRICHOGRAPTUS**, *Nicholson.*

1876. *Trichograptus*, Nicholson, Geol. Mag., dec. 2, vol. iii, p. 248.

Polypary bilaterally symmetrical, consisting of two very slender, reclined, uniserial main stipes, from the thecal margins of which long, slender, flexed lateral branches are given off.

Thecæ approximately of the simple Dichograptid type, overlapping for a very small fraction of their length.

This genus might be regarded as intermediate in character between the Dichograptidæ and the Leptograptidæ. It approaches closely to *Cœnograptus* (of Hall) in the tenuity of its stipes and general mode of branching. Its characters in many respects approximate also to those of *Pterograptus*, Holm; but the angle of divergence of the two main stipes, which in that genus is less than 90°, is here over 180°. The form of the thecæ, however, so far as can be made out, appears to link it rather with the Dichograptidæ than the Leptograptidæ. Hence it seems best, in the present state of our knowledge, to regard it theoretically as a very slender reclined compound *Didymograptus*, from the thecal margins of which simple lateral branches are given off.

Only one British species has yet been recorded, viz. *Trichograptus fragilis*.

Trichograptus fragilis (Nicholson). Plate XII, fig. 5.

1869. *Dichograpsus fragilis*, Nicholson, Ann. Mag. Nat. Hist. [4], vol. iv, p. 232, pl. xi, figs. 1—3.
1876. *Trichograptus fragilis*, Nicholson, Geol. Mag., dec. 2, vol. iii, p. 248.
1898. *Trichograptus fragilis*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 476.

Main stipes straight, 1 cm. or more in length, originating from a conspicuous sicula, and converging upward and backward upon the nema; from their thecal margins three (or more) lateral branches are given off near the proximal end. Thecæ nine to ten in 10 mm., inclined at 28°, average length 1·5 mm., three to four times as long as wide; outer walls straight, overlapping one quarter to one third their length. Apertural margins normal, straight.

Description.—The whole polypary is very small; the main stipes seem rather straighter than the lateral branches, which have a length of about 2 cm. All the stipes are characteristically slender and thread-like, having an average width of ·5 mm. The first lateral stipe is given off at a distance of about 1 mm. from the sicula, and there is a distance of about 1·4 mm. between each of the others. This first seems to originate at about the length of a single theca from the sicula.

Fig. 53.—*Trichograptus fragilis*, Nicholson.

Thecæ on one of the lateral branches. Enlargement of Pl. XII, fig. 5.

The sicula is small, measuring only ·5 mm. in length; nevertheless it is conspicuous, owing to the extreme tenuity of the stipes.

Affinities.—*T. fragilis* may be distinguished from all other Dichograptidæ by its extreme tenuity and its mode of growth.

Horizon and Localities.—Llanvirn, Upper Skiddaw Slates.

Lake District: Thornship Beck, near Shap; Ashlock Sike.

Associates, etc.—The associates of *T. fragilis* are

unknown, and up to the present time it has only been recorded from the Skiddaw Slates. Two specimens only are known to us; both of these belonged originally to Nicholson, and are now in the Natural History Museum, South Kensington.

NOTE.

There remain two so-called genera to be described in this connection. These are *Azygograptus* of Lapworth, and *Phyllograptus* of Hall.

Azygograptus has wholly lost the power of dichotomy, so characteristic of the typical members of the Dichograptid family; and the genus includes within it, as at present understood, a form showing characters approximating in some respects to those of the Leptograptidæ.

Phyllograptus, while fully retaining the thecal characters of the Dichograptidæ, and their power of dichotomy, has acquired more or less the outward *habit* of *Diplograptus*.

Genus **AZYGOGRAPTUS**, *Nicholson* and *Lapworth*.

1875. *Azygograptus*, Nicholson, Ann. Mag. Nat. Hist. [4], vol. xvi, p. 269.
1898. *Azygograptus*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 153.

Polypary simple, unilateral, consisting of a single stipe originating from the sicula at various levels, and bearing thecæ on one side only.

Thecæ distant, overlap small, inclination uniformly low.

The original description of this genus was founded on the characters of *Az. Lapworthi*, and it was regarded as belonging to the family Leptograptidæ (Nemagraptidæ). But abundant examples of *Az. Lapworthi* subsequently obtained, show that this species at any rate possesses the ordinary characters of some of the slender forms which are grouped with the Dichograptidæ (for example, *Didymo. gracilis*), and thus the type species in this genus is consequently best regarded as a Dichograptid in which the power of dichotomy is altogether lost. This conclusion would in the meantime carry with it the systematic position of the entire genus as at present understood. Two out of the three other known species of the genus present similar characters; but the third (*Az. cœlebs*) shows in certain particulars an approach to the Leptograptidæ, and might perhaps be regarded as a transitional form between the two families.

Holm has described a form ('Geol. Fören. Förhandl.,' Bd. xvii, H. 3, p. 339) which he believes is intermediate between *Didymograptus* and *Azygograptus*. In a normal *Didymograptus*, as already described, there are present a *primary stipe* and a *second stipe*, communicating with each by means of a *crossing canal;* in Holm's intermediate form there is a *primary stipe* and a *crossing canal*, but no *second stipe* is developed: the form is, in fact, an *aborted Didymograptus*. Obviously, there-

fore, further abortion might lead to the non-development of the apparently functionless *crossing canal:* and this seems to be precisely what we have in *Azygograptus.*

The Azygograpti fall into three groups, according to the characters of the stipe and the thecæ; these groups are as follows:

Group I. Type *Az. Lapworthi.*
Az. Lapworthi.
Az. Hicksii.
Group II. Type *Az. suecicus.*
Az. suecicus.
Group III. Type *Az. cœlebs.*
Az. cœlebs.

Group I.—Type *Az. Lapworthi.*

Azygograpti in which the dorsal wall of the stipe has a graceful convex curvature; the stipe originates at a point on the sicula midway between the apex and the aperture, and grows at once outward; the thecæ are large, and the amount of overlap is small.

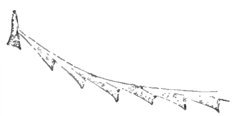
Azygograptus Lapworthi, Nicholson. Plate XIII, figs. 1 *a*, *b*.

1875. *Azygograptus Lapworthi,* Nicholson, Ann. Mag. Nat. Hist. [4], vol. xvi, p. 269, pl. vii, figs. 2, 2 *c*.
1898. *Azygograptus Lapworthi,* Elles, Quart. Journ. Geol. Soc., vol. liv, p. 513.

Stipe considerably curved, 2·5 to 5 cm. in length, slender at origin, but gradually increasing up to a maximum width of about 1 mm.; originating from a conspicuous sicula at a point about midway between the apex and aperture. Thecæ seven to eight in 10 mm., long and narrow, four to four and a half times as long as wide, and widening towards their apertures; outer walls straight, or with slight concave curvature near the sicula; inclination 20°, in contact only. Apertural margins straight, perpendicular.

Description.—The stipe is always convexly curved; it is slender at its origin, the width opposite the aperture of the first theca rarely exceeding ·5 mm., but it increases steadily till it reaches the maximum of about 1 mm.

Fig. 54.—*Azygograptus Lapworthi,* Nicholson.



Proximal end. Enlargement of one of specimens on Pl. XIII, fig. 1 *a*.

The sicula is large and conspicuous; when complete it measures fully 1·5 mm. in length (Nicholson's measurement is somewhat less), and is always completely free in its apertural region. Occasionally transverse rings may be seen very near the apical end.

The first theca appears to grow out from the sicula at a point midway between the apex and the aperture, and curves away at once; hence the connection between the stipe and the

sicula is very slender, and as a consequence the stipe is frequently found broken at this point. The length of a mature theca is about 2·5 mm.

Affinities.—*Azygograptus Lapworthi* resembles some examples of *Az. Hicksii* in the curvature of the stipe, but differs in having shorter and more closely set thecæ. From the other two species—*Az. cœlebs* and *Az. suecicus*—it can be easily separated by the curvature of its stipe and the position on the sicula at which the stipe originates.

Horizon and Locality.—Arenig, Middle Skiddaw Slates (*Dichograptus* beds). *Lake District:* Hodgson How Quarry, near Portinscale.

Associates, etc.—Up to the present time this species has only been recorded from the Skiddaw Slates, where it is very abundant at a certain horizon. It has not been found associated with any other forms. Several good specimens are in the collections of the Keswick Natural History Museum, the Woodwardian Museum, the British Museum, and in the private collections of Lapworth, Nicholson, Postlethwaite, and the authors.

Azygograptus Hicksii (Hopkinson sp.). Plate XIII, figs. 2 *a*—*e*.

1875. *Tetragraptus Hicksii*, Hopkinson, Quart. Journ. Geol. Soc., vol. xxxi, p. 651, pl. xxxiii, figs. 12 *a*—*d*.

Stipe considerably curved, 2·5 to 7·5 cm. in length, slender at origin, but quickly attaining a maximum width of about 1·6 mm., originating from a conspicuous sicula at a little distance above its aperture. Thecæ four to five in 10 mm., very long tubes, three times as long as wide, widening gradually in the direction of their apertures, with concavely curved outer walls; inclination 10° to 15°, overlap increasing from mere contact to one third their length. Apertural margins slightly concave, oblique.

Description.—The stipe is slender at its origin, being about ·9 mm. in breadth, but it widens rapidly up to about 1·6 mm., and thereafter no further increase takes place even in stipes having a length of 7·6 cm.

FIG. 55 *a*.—*Azygograptus Hicksii*, Hopkinson.

Proximal end. Enlargement of Pl. XIII, fig. 2 *d*.

The sicula is conspicuous but narrow; it has a length of 1·7 mm. The first theca originates approximately in the centre of the sicula, grows slightly downward, and then sometimes curves outward in a manner recalling that of *Az. Lapworthi;* but the amount of curvature of the stipe varies considerably in different individuals, though it is always convex.

The thecæ are about 3 mm. in length; they are inclined from 10° to 15°. In the proximal region of

FIG. 55 *b*.—*Azygograptus Hicksii*, Hopkinson.

Distal thecæ. Whitesand Bay. Coll. Woodwardian Museum.

the stipe they are in contact only, but they may overlap for one third of their length in the distal portion. The apertural margins are straight or slightly concave, and according to preservation may appear perpendicular or oblique.

Affinities.—*Az. Hicksii* somewhat resembles *Az. Lapworthi* in the mode of origin and curvature of its stipe; it can, however, be readily distinguished from that form by its longer and more distant thecæ. The curvature of the stipe, and its mode of origin, also distinguish it from the two other known species, *Az. cœlebs* and *Az. suecicus*.

Remarks.—This form, originally described by Hopkinson as a *Tetragraptus*, is a well-marked *Azygograptus*. We refigure the type specimens (Pl. XIII, figs. 2 *a*—*c*), and it will be seen that the apparent branching is due to the accidental association of several stipes, the direction of the thecæ showing that they belong to several individuals. In the specimen figured by Hopkinson as 12 c and 12 d, the structure at the termination of the stipe, which looks like a fragment of another stipe, is the sicula; and in addition to the forms figured by him, there are several well-preserved specimens in the same collection in which the proximal end is complete. It is a characteristic habit of this form that several individuals should occur together in more or less tangled confusion.

Horizon and Locality.—Middle Arenig (of Hicks).

St. David's District: Whitesand Bay.

Associates, etc.—*Azygograptus Hicksii* has not yet been found associated with any other fossils. All the specimens known to us come from the Middle Arenig rocks of Whitesand Bay. They were collected by Hicks and Hopkinson, and by them were presented to the Woodwardian Museum.

Group II.—Type *Az. suecicus*.

Azygograpti in which the stipe generally grows rigidly outward and downward; and, originating slightly above the aperture of the sicula, is appressed to the latter for a short distance; the thecæ are long and narrow, and the amount of overlap is small.

Azygograptus suecicus, Moberg. Plate XIII, figs. 3 *a*—*b*.

1891. *Azygograptus succicus*, Moberg, Geol. Fören. Förhandl., vol. xiv, p. 342, pl. viii, figs. 1 and 2.
1898. *Azygograptus suecicus*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 514, fig. 29.

Stipe rigid or with very slight curvature, 1—4 cm. in length, of a uniform width of ·8 mm., growing straight downward from the aperture of a

conspicuous sicula, and making with it an angle of 145°. Thecæ seven to eight in 10 mm., long narrow tubes; outer walls with slight double curvature, seven times as long as wide, proximally in contact only, but overlap increasing distally to one third their length; inclination 15°. Apertural margins straight, acute, perpendicular.

Fig. 56.—*Azygograptus suecicus*, Moberg.

Proximal end, showing sicula. Figured Elles, 'Quart. Journ. Geol. Soc.,' vol. liv, p. 515, fig. 29. Enlargement of one of the specimens on Pl. XIII, fig. 3 *a*.

Description.—The sicula is very long and narrow, being fully 1·6 mm. in length; the stipe appears to arise close to the aperture, but in reality the first theca arises slightly higher up, and is appressed to the side of the sicula for a short distance, and then grows straight downward beyond its aperture. The average length of each mature theca is about 2 mm.

Affinities.—The size and generally rigid look of the whole polypary furnish characters whereby this species can be readily distinguished from *Az. Lapworthi* or *Az. Hicksii.* The stipe very rarely approaches the horizontal direction of growth characteristic of *Az. cœlebs*, from which species it may further be separated by the form and number of the thecæ.

Horizon and Localities.—Arenig, Middle Skiddaw Slates (Upper *Tetragraptus* beds).

Lake District: Barf; north-east Sleet How, west of Braithwaite; Carlside Edge. *Lleyn Peninsula:* Parwyd.

Associates, etc.—*A. suecicus* has, up to the present time, only been recorded in Britain from the Skiddaw Slates and the Upper Arenig beds of the Lleyn Peninsula, where it occurs in association with *D. hirundo* and *D. gibberulus.* It is abundant at a corresponding horizon in Sweden, and seems to occur with the same associates. Good specimens are known in the collections of the Keswick Natural History Museum, the Woodwardian Museum, and in Postlethwaite's private collection.

Group III.—Type *Az. cœlebs.*

Azygograpti in which the stipe grows in a horizontal direction; but, originating near the apex of the sicula, is appressed to the latter throughout its length; the thecæ are long and narrow, and the amount of overlap is small.

Azygograptus cœlebs, Lapworth. Plate XIII, figs. 4 *a*, *b*.

1880. *Azygograptus cœlebs*, Lapworth, Ann. Mag. Nat. Hist. [5], vol. v, p. 159, pl. v, figs. 16 *a*—*c*.
1898. *Azygograptus cœlebs*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 514.

Stipes very slightly curved, 1·5 to 5 cm. in length and of uniform width of about ·5 mm., apparently growing out from the major extremity of a small but relatively broad sicula in a direction perpendicular to its long axis. Thecæ ten in 10 mm., narrow tubes of uniform width, seven times as long as wide, inclined at 15°, in contact for more than half their length near the sicula, but with overlap diminishing distally; outer walls with slight double curvature. Apertural margins acute, straight, facing slightly inward.

Description.—The stipes may be as long as 5 cm.; they occur, however, more commonly in a fragmentary condition not exceeding 1·5 cm. in length.

FIG. 57 *a*.—*Azygograptus cœlebs*, Lapworth.

Type specimen, showing details of proximal end in relief. Figured Lapworth, 'Ann. and Mag. Nat. Hist.' [5], vol. v, pl. v, figs. 10 *a*, *b*. Ellergill. Coll. Lapworth.

The sicula is small and broad, but is nevertheless quite conspicuous; it measures about ·9 mm. in length, and is considerably shorter and wider than that of *Az. Lapworthi.* The thread-like virgula growing from the apex of the sicula can occasionally be detected.

The earliest theca generally *appears* to arise close to the aperture of the sicula, but in well-preserved specimens it can be seen that the actual point of origin is near its apex, and that throughout its earliest period of growth the theca is closely appressed to one side of the sicula, but after reaching the apertural region it takes a sudden curve outward, and all the thecæ subsequently developed are straight and practically horizontal.

FIG. 57 *b*.—*Azygograptus cœlebs*, Lapworth.

Distal thecæ. Enlargement of Pl. XIII, fig. 4 *b*.

The average length of each mature theca is nearly 2 mm., and even the earliest formed ones appear to be of the same length. The amount of overlap decreases from one half to two thirds at the proximal end to a quarter towards the distal end. The thecæ show an approach to the Leptograptid type both in the form of their apertures and in the slight double curvature of their walls.

Horizon and Locality.—Llanvirn, Upper Skiddaw Slates (Ellergill beds).

Lake District: Ellergill.

Associates, etc.—Up to the present time *Az. cœlebs* has only been recorded from the Skiddaw Slates, and is apparently confined to the highest beds of that series, where it occurs in association with *Diplog. dentatus*; but it is always rather rare.

The best specimens are in Lapworth's collection and that of the Woodwardian Museum.

Characters of the different species of Azygograpti.

	Group I.		Group II.	Group III.
	Az. Lapworthi	*Az. Hicksii.*	*Az. suecicus.*	*Az. cœlebs.*
Character of stipe	Flexed	Flexed	Rigid.	Straight and horizontal
Maximum width of stipe	1 mm.	1·6 mm.	0·8 mm.	0·5 mm.
Length of sicula	1·5 mm.	1·7 mm.	1·6 mm.	0·9 mm.
Origin of th. 1^1	Central	Central	Suboral	Apical
No. of thecæ in 10 mm.	7—8	4—5	7—8	10
Inclination	20°	10°—15°	15°	15°
Overlap	0	0—$\frac{1}{3}$	0—$\frac{1}{3}$	$\frac{1}{2}$—$\frac{1}{4}$
Average apertural angle	90°	90°—100°	90°	85°

Genus **PHYLLOGRAPTUS,** *Hall.*

1858. *Phyllograptus,* Hall, Geol. Survey Canada Rep., 1857, p. 135.

Polypary foliiform, bilaterally symmetrical, consisting of four uniserial main stipes, which are produced by dichotomous division from a primitive *Didymograptus* stage, and which coalesce by the whole of their dorsal surfaces. Sicula embedded.

Thecæ single cylindrical or subcylindrical tubes of approximately uniform width, usually in contact throughout their length.

The species included in this genus constitute a group which might almost cause them to be regarded as merely a *scandent series* of Tetragrapti, were it not that a new feature is introduced into their structure whereby the stipes are actually fused along the entire length of their dorsal walls, and constitute as it were two intersecting ovals.

The initial stages of development appear to be in all respects comparable with those described for *Tetragraptus.*

Phyllograptus, cf. **typus**, Hall. Plate XIII, figs. 5 *a*, *b*.

1858. *Phyllograptus typus*, Hall, Geol. Survey of Canada Rep., 1857, p. 137.
1865. *Phyllograptus typus*, Hall, Graptolites of the Quebec Group, p. 119, pl. xv, figs. 1—12.
1868. *Phyllograpsus typus*, Nicholson, Quart. Journ. Geol. Soc., vol. xxiv, p. 133, pl. v, fig. 16.
1898. *Phyllograptus typus*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 494.

Stipes united so as to form a polypary with elongate-ovate, broad oval, or obovate outlines. Thecæ nine to ten in 10 mm., direction of growth and curvature varied, five to six times as long as wide; in contact throughout their length. Apertural margins concave, mucronate, very oblique.

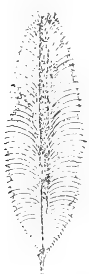
Description.—This species is exceedingly variable in form, the known length in our British examples ranging from 31 to 57 mm., and the breadth from 6·3 to 10·5 mm.

The variation in shape appears to be largely dependent upon the amount of curvature of the thecæ, which varies very much in different individuals.

The thecæ are curved throughout the whole length of the polypary; they are nearly horizontal in the proximal part, but curve back so that the aperture is directed downward. The curvature is less in the middle of the stipe, and the line of the aperture becomes parallel to the general direction of the polypary. Above this the aperture becomes oblique, and the thecæ are inclined at higher and higher angles, so that eventually, at the distal end, the apertures of the thecæ lie almost perpendicularly with regard to the axis of the polypary, a complete change in direction having thus been effected.

The sicula appears to be 1·6 mm. in length, and the first theca is developed from near the apical end. There is occasionally a spinous projection from the base of the sicula.

Fig. 58.—*Phyllograptus typus*, Hall.



Specimen from Hall's original locality, nat. size, for comparison with British examples. Beach below Pt. Levis, Quebec. Coll. Canadian Geological Survey.

Affinities.—The British specimens here doubtfully referred to *Phyllograptus typus* are never so large as the typical American form, and do not as a rule show the prominent sicular spine so conspicuous in the American examples; at the same time they have not the characteristic appearance of *Phyllog. angustifolius.* Although their relative proportions as regards length and width are comparable with the American form, yet the foregoing distinctions may possibly some day show them to be a distinct variety. Since, however, our specimens have all been much affected by cleavage, and are generally more or less indifferently preserved, we prefer to refer them provisionally to Hall's species. For the

purposes of comparison we give a figure of one of the Canadian specimens, in the collection of the Canadian Geological Survey, from Hall's typical locality at the beach below Point Levis.

Horizon and Localities.—Arenig, Middle Skiddaw Slates (upper beds).

Lake District: Barf; Whiteside; Carlside; Randal Crag; Thornship Beck; Glenderamakin Valley; Mungrisedale.

Associates, etc.—*P.*, cf. *typus*, is not an abundant form in the Skiddaw Slates. It occurs in the upper beds of the Middle Skiddaw Slates associated with *P. angustifolius.* It has also been recorded by the Geological Survey of Scotland from the Arenig beds of Bennane Head, but it is doubtful whether the specimens belong to *P. typus.*

The best specimens known to us are in the Woodwardian Museum and the Keswick Museum, in Postlethwaite's collection, and in the Natural History Museum, South Kensington.

Phyllograptus angustifolius, Hall. Plate XIII, figs. 7 *a*—*f*.

1858. *Phyllograptus angustifolius*, Hall, Geol. Survey Canada Rep., 1857, p. 139.
1863. *Phyllograptus angustifolius*, Salter, Quart. Journ. Geol. Soc., vol. xix, p. 137, figs. 7 *a*, *b*.
1865. *Phyllograptus angustifolius*, Hall, Grapt. of Quebec Group, p. 125, pl. xvi, figs. 17—21.
1868. *Phyllograpsus angustifolius*, Nicholson, Quart. Journ Geol. Soc., vol. xxiv, p. 132.
1898. *Phyllograptus angustifolius*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 496.

Stipes united so as to form an elongate-ovate polypary of variable length and breadth. Thecæ eleven to thirteen in 10 mm., inclination increasing steadily towards the distal end, three times as long as wide, free for a small fraction of their length near the aperture. Apertural margins concave, with conspicuous denticle, very oblique.

Description.—The dimensions of this species vary greatly in different individuals; the length may be anything below 50 mm., and the width may be as great as 8·7 mm., but is more commonly 4·2 or 4·8 mm. The greatest breadth is generally attained near the base of a long specimen, and, in fact, the polypary is often wider there than at any subsequent point along its length.

The curvature of the thecæ is very similar to that of *P.*, cf. *typus*, the thecæ at the proximal end coming out nearly horizontally, and then curving slightly back and down; but the subsequent curvature is far more uniform than is the case with *P.*, cf. *typus*, where there is an appreciable diminution in the centre of the polypary.

The form of the thecal aperture with its long denticle is characteristic, there being a greater extension on the lower than on the upper side; this denticle may be one and a half times as long as the width of the thecæ (1 mm.).

Affinities.—The shorter and broader forms of *P. angustifolius* approach *P.*, cf. *typus* in general shape, but can be distinguished by—

(1) the form of the thecal aperture,

(2) the greater number of thecæ in a given unit of length.

Fig. 59.—*Phyllograptus angustifolius*, Hall.

Distal thecæ in relief, showing form of aperture. Enlargement of Pl. XIII, fig. 7 *e*. × 5.

Horizon and Localities.—Arenig, Middle Skiddaw Slates.

Lake District : Barf; Carlside; Whiteside; Randal Crag; Bassenthwaite Sand-beds; Knott Head, Whinlatter; Ellergill.

Associates, etc.—*P. angustifolius* has as yet only been recorded from the Skiddaw Slates, where it seems to be a very abundant form; numerous specimens collected from various localities are in the collections of the Woodwardian Museum, the Keswick Museum, the British Museum, and in the private collections of Postlethwaite and the authors. It occurs associated with *P. typus*, *P. anna*, *Tetragraptus Bigsbyi*, and *Dichograptus octobrachiatus*, and would thus seem to have had a fairly long range in time.

Phyllograptus anna, Hall. Plate XIII, figs. 6 *a*—*f*.

1865. *Phyllograptus anna*, Hall, Grapt. of Quebec Group, p. 124, pl. xvi, figs. 11—16.
1898. *Phyllograptus anna*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 494, fig. 16.

Stipes forming the polypary united so as to form two small narrow intersecting ovals, which are widest in their central portions. Thecæ fourteen to sixteen in 10 mm., direction of growth constant, curvature varied in amount, three times as long as wide, in contact throughout their length. Apertural margins concave, mucronate, oblique.

Description.—The polypary is always very small; none of the specimens exceed 12·7 mm. in length; they appear to be commonly about 10·5 mm. long, and have a maximum width of 5 mm., which is attained a little distance below the distal extremity.

Figs. 60 *a* and *b*.—*Phyllograptus anna*, Hall.

a. b

a. Impression of proximal end, showing indications of virgula. Enlargement of Pl. XIII, fig. 6 *c*.
b. Proximal end. Enlargement of Pl. XIII, fig. 6 *f*.

The polypary seems to be developed on the same general plan as that indicated by Holm for the species *P. angustifolius*. The sicula is long, probably about 2 mm., and the first theca, which appears to arise near to its apical end, resembles the sicula

in form. The line of the virgula seems to be indicated, but it terminates with the polypary, or, at any rate, has never been observed to project beyond it. All the thecæ are curved, and are directed upward and outward, though the curvature decreases from the proximal to the distal extremity of the polypary.

Affinities.—*P. anna* is characterised by its small size and closely set thecæ; these particulars serve to separate it from all other known species except *P. ilicifolius*, from which it can, however, be distinguished by the constant direction of curvature of the thecæ as contrasted with the change in direction of growth of the thecæ of *P. ilicifolius.*

Horizon and Localities.—Arenig, Middle Skiddaw Slates.

Lake District: Randal Crag, Skiddaw; Barf; Carlside Edge. *South Scotland:* Bennane Head, Ballantrae.

Associates, etc.—*P. anna* occurs in some abundance at certain horizons in the Skiddaw Slates associated with *P. angustifolius.* Specimens are in the collection of the Woodwardian Museum and in Lapworth's and Postlethwaite's private collections.

Phyllograptus ilicifolius, var. **grandis**, Elles. Plate XIII, fig. 8.

1898. *Phyllograptus ilicifolius*, var. *grandis*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 493, fig. 15.

Stipes constituting the polypary so united as to form two broad intersecting ovals, each of which is widest at its upper end. Thecæ eleven to thirteen in 10 mm., amount of curvature and direction of growth varied, four and a half times as long as wide, and in contact throughout their length. Apertural margins concave, mucronate, oblique.

Description.—The polypary has a length of 25 mm. and a maximum width of 15 mm. The curvature and direction of growth of the thecæ in different parts of the polypary are highly characteristic; near the proximal end they first ascend, and then curve out and down; in the centre of the stipe they are so slightly arcuate that they appear almost horizontal; while toward the distal extremity they are directed outward and upward, and ultimately almost straight upward.

Affinities.—*P. ilicifolius*, var. *grandis*, closely resembles those specimens of *P. ilicifolius* which Hall has figured, but it is three times the size of the Canadian forms.

Horizon and Locality.—Arenig, Middle Skiddaw Slates.

Lake District: north-east Sleet How, Keswick.

Associates, etc.—The associates of this form are unknown. The type specimen is in the Woodwardian Museum.

PLATE V.

Genus **Tetragraptus,** Salter.

FIGS.

1 *a—e.—Tetragraptus quadribrachiatus* (Hall).

1 *a.* Fairly preserved example from Outerside. Skiddaw Slates. British Museum (Natural History), S. Kensington.

1 *b.* Specimen indifferently preserved. Haykin Gill. Skiddaw Slates. Woodwardian Museum.

1 *c.* Ibid. Randal Crag. Skiddaw Slates. Postlethwaite's Collection.

1 *d.* Small specimen, well preserved, showing details of thecæ. Barf. Skiddaw Slates. Woodwardian Museum.

1 *e.* Single stipe. Figured, Hopkinson, Quart. Journ. Geol. Soc., 1875, pl. xxxiii, figs. 9 *a*, *b*. Whitesand Bay. Middle Arenig (Hicks). Woodwardian Museum.

2.—*Tetragraptus crucifer* (Hall).

Poorly preserved specimen, but showing disc. Barf. Skiddaw Slates. Postlethwaite's Collection.

3 *a*, *b*.—*Tetragraptus Headi* (Hall).

3 *a.* Indifferently preserved specimen, showing large disc. Randal Crag. Skiddaw Slates. Postlethwaite's Collection.

3 *b.* Very large specimen, without disc. Randal Crag. Skiddaw Slates. Lapworth's Collection.

4 *a—c.—Tetragraptus Amii*, Lapworth, MS.

4 *a.* Specimen well preserved, but showing three complete stipes only. White Horse, N.W. of Skiddaw, above Barkbath Dale. Skiddaw Slates. Woodwardian Museum.

4 *b.* Typical form. On same slab as 4 *a*.

4 *c.* Specimen distorted by cleavage. Figured by Hopkinson as *Tetragraptus serra*, Quart. Journ. Geol. Soc., 1875, pl. xxxiii, fig. 10. Whitesand Bay. Woodwardian Museum.

PLATE V.

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TETRAGRAPTUS.

PLATE VI.

Tetragraptus (*continued*) and **Schizograptus,** Nicholson.

FIGS.

1 *a, b.*—*Tetragraptus Postlethwaiti*, Elles.

1 *a.* Typical form, reverse view. Figured, Elles, Quart. Journ. Geol. Soc., 1898, vol. liv, p. 492, fig. 14 *b.* Carlside Edge. Skiddaw Slates. Postlethwaite's Collection.

1 *b.* Incomplete specimen, showing only three stipes. Ibid., fig. 14 *c.*

2 *a, b.*—*Tetragraptus fruticosus* (Hall).

2 *a.* Fragment, obverse view. Bennane Head, Ballantrae. Lapworth's Collection.

2 *b.* Another fragment. Ibid.

3 *a—d.*—*Tetragraptus pendens*, Elles.

3 *a.* Long specimen. Figured, Elles, Quart. Journ. Geol. Soc., 1898, vol. liv, p. 491, fig. 13. Barf. Skiddaw Slates. Postlethwaite's Collection.

3 *b.* Ibid., fig. 13, *op. cit.*

3 *c.* Ibid., fig. 13, *op. cit.* The three foregoing specimens are preserved upon the same slab.

3 *d.* Reverse view, specimen preserved as an impression. Barf. Skiddaw Slates. Postlethwaite's Collection.

4 *a—f.*—*Tetragraptus serra* (Brongniart).

4 *a.* Large form, preserved partly as a cast, partly as an impression. Great Knot, Randal Crag. Skiddaw Slates. Woodwardian Museum.

4 *b.* Specimen preserved as an impression, showing sicula. Randal Crag. Skiddaw Slates. Woodwardian Museum.

4 *c.* Compressed specimen. Figured by Hopkinson as *T. Halli*, Quart. Journ. Geol. Soc., 1875, vol. xxxi, pl. xxxiii, fig. 11 *a.* Whitesand Bay. Middle Arenig. Woodwardian Museum.

4 *d.* Ibid., fig. 11 *b*, *op. cit.*

4 *e.* Specimen showing two stipes only. Carlside Edge. Skiddaw Slates. Postlethwaite's Collection.

4 *f.* Narrower form. Outerside. Skiddaw Slates. British Museum (Natural History), S. Kensington.

5 *a—e.*—*Tetragraptus reclinatus*, Elles and Wood, sp. nov.

5 *a.* Two specimens in association. Whinlatter. Skiddaw Slates. Postlethwaite's Collection.

5 *b.* Reverse aspect of 5 *a*, showing form of thecæ.

5 *c.* Two specimens in association. Randal Crag. Skiddaw Slates. Postlethwaite's Collection.

5 *d.* Distorted specimen. Carlside Edge. Skiddaw Slates. Fitz-Park Museum, Keswick.

5 *e.* Specimen showing sicula. On same slab as 5 *d.*

6 *a—e.*—*Tetragraptus Bigsbyi* (Hall).

6 *a.* Specimen presenting the typical form. Skiddaw Slates. Lapworth's Collection.

6 *b.* Form showing sicula, preserved as an impression. White Horse Fell. Skiddaw Slates. Woodwardian Museum.

6 *c.* Well-preserved specimen; an impression. Bassenthwaite Sand-beds. Skiddaw Slates. Woodwardian Museum.

6 *d.* Specimens with stipes distally overlapping or conjoined. Troutbeck Beck. Skiddaw Slates. Lapworth's Collection.

6 *e.* Ibid.

7.—*Schizograptus reticulatus*, Nicholson.

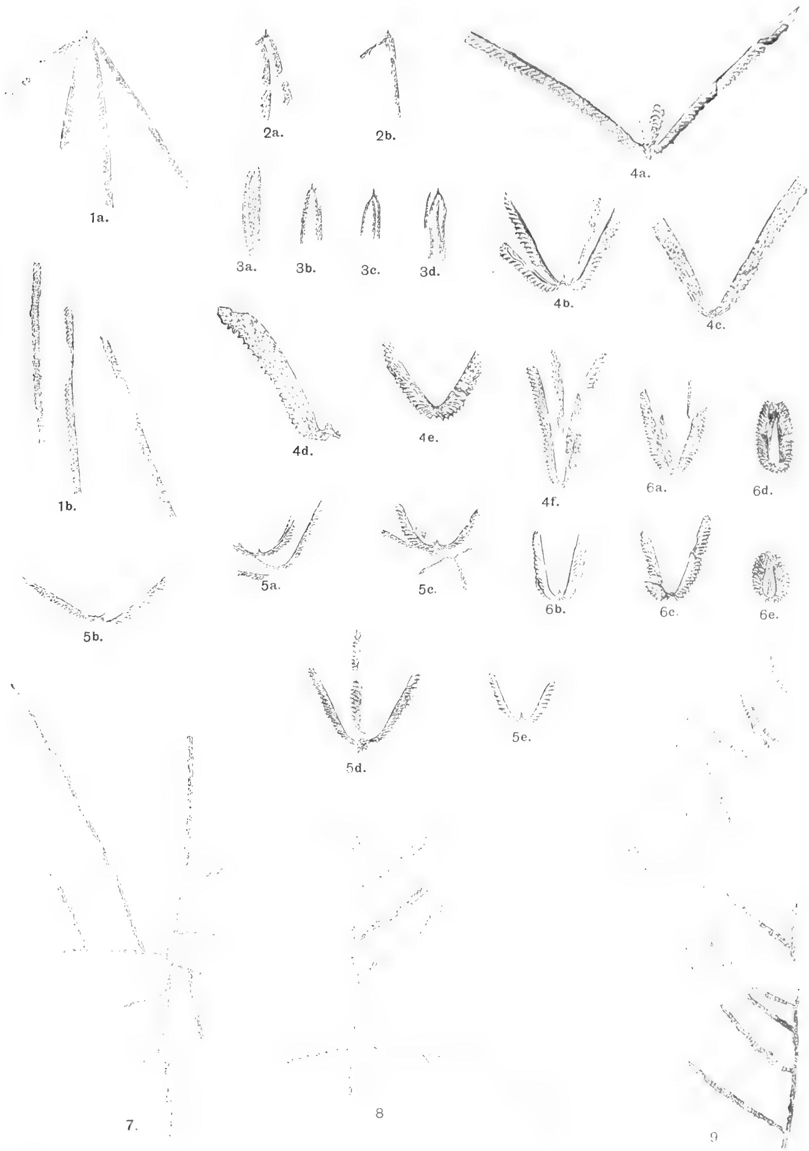
Type specimen. Figured, Nicholson, Quart. Journ. Geol. Soc., 1868, vol. xxiv, pl. v, fig. 4. Scale Hill, Crummock. Skiddaw Slates. British Museum (Natural History), S. Kensington.

8.—*Schizograptus tardifurcatus*, Elles.

Type specimen. Figured, Elles, Quart. Journ. Geol. Soc., 1898, vol. liv, p. 481, fig. 7. Carlside Edge. Skiddaw Slates. Postlethwaite's Collection.

9.—*Schizograptus* or *Trochograptus*.

Type specimen of Nicholson's *Pleurograptus vagans*, Nich., Quart. Journ. Geol. Soc., 1868, vol. xxiv, pl. vi, figs. 4, 5. Scale Hill, near Crummock. Skiddaw Slates. Postlethwaite's Collection.



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TETRAGRAPTUS AND SCHIZOGRAPTUS.

PLATE VII.

Genus **Trochograptus**, Holm.

FIG.

1.—*Trochograptus diffusus*, Holm.

Specimen showing disc. Figured, Elles, Quart. Journ. Geol. Soc., vol. liv, pl. xxvii. New Quarry, Scow Gill. Middle Skiddaw Slates. Fitz-Park Museum, Keswick.

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TROCHOGRAPTUS.

PLATE VIII.

Genus **Trochograptus** (*continued*) and **Holograptus**, Holm.

FIGS.

1 *a*, *b*.—*Trochograptus diffusus*, Holm.

1 *a*. Large specimen, one fifth natural size. New Brow Quarry, Upper Lorton. Middle Skiddaw Slates. Woodwardian Museum.

1 *b*. Diagrammatic sketch of portion of 1 *a*, natural size, showing method of branching.

2 *a*—*c*.—*Holograptus Deani*, Lapw., MS.

2 *a*. Very large specimen, one fifth natural size. Newlands, near Buttermere. Skiddaw Slates. Lapworth's Collection.

2 *b*. Part of branch, natural size, showing the form of the thecæ.

2 *c*. Part of 2 *a*, natural size, showing method of branching.

1a.

2b.

2c.

1b.

2a.

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TROCHOGRAPTUS AND HOLOGRAPTUS.

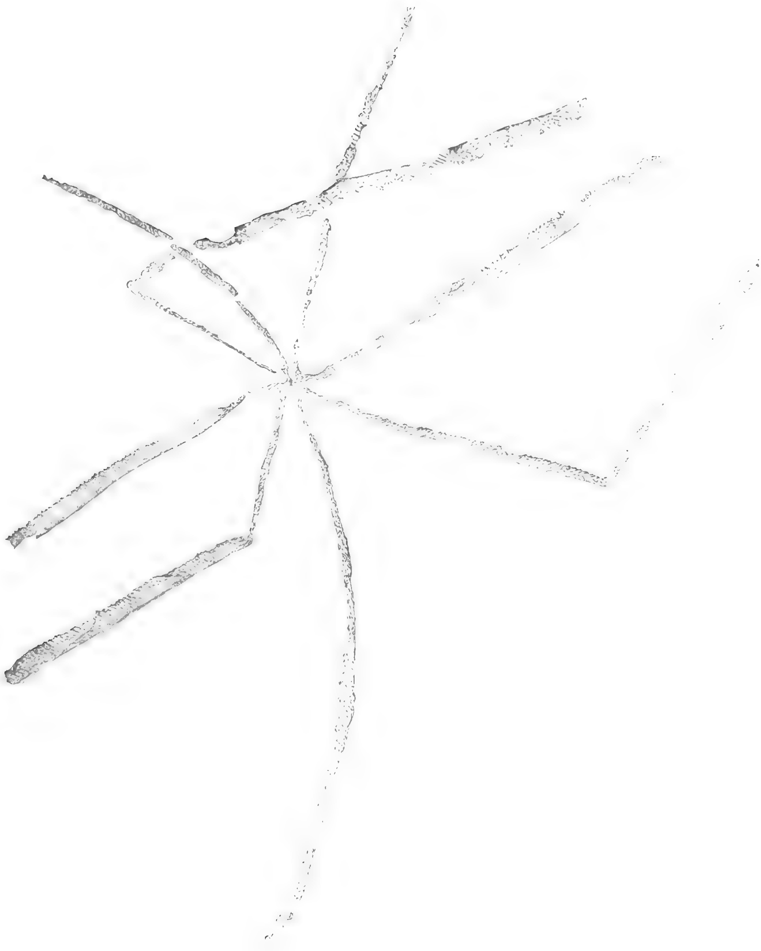
PLATE IX.

Genus **Dichograptus**, Salter.

FIG.

1 *a.*—*Dichograptus octobrachiatus* (Hall).

Large specimen with eight stipes, showing faint indication of a disc. Randal Crag. Skiddaw Slates. Woodwardian Museum.



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DICHOGRAPTUS.

PLATE X.

Dichograptus—(*continued*).

FIGS.

1 *a—e.*—*Dichograptus octobrachiatus* (Hall).

1 *a.* Small specimen, less rigid than usual. Slape Crags, above Hope Gill, Brackenthwaite. Skiddaw Slates. Woodwardian Museum.

1 *b.* Rigid form, preserved partly as a cast; seven stipes only. ? Figured by Salter as *D. aranea*, Quart. Journ. Geol. Soc., 1863, vol. xix, p. 137, fig. 9. Skiddaw Slates. Museum of Practical Geology, Jermyn Street.

1 *c.* Eight-stiped form, showing a well-marked central disc. Skiddaw Slates. Museum of Practical Geology, Jermyn Street.

1 *d.* Large six-stiped form. Randal Crag. Skiddaw Slates. Woodwardian Museum.

1 *e.* Small five-stiped form. Randal Crag. Skiddaw Slates. Woodwardian Museum.

2.—Fragments of Dichograptid stipes.

Original specimen of M'Coy's *G. latus.* Figured, M'Coy, Quart. Journ. Geol. Soc., 1848, vol. iv, p. 223. Knockmurton. Skiddaw Slates. Woodwardian Museum.

3 *a, b.*—*Dichograptus octobrachiatus*, var. *Sedgwickii*, Salter.

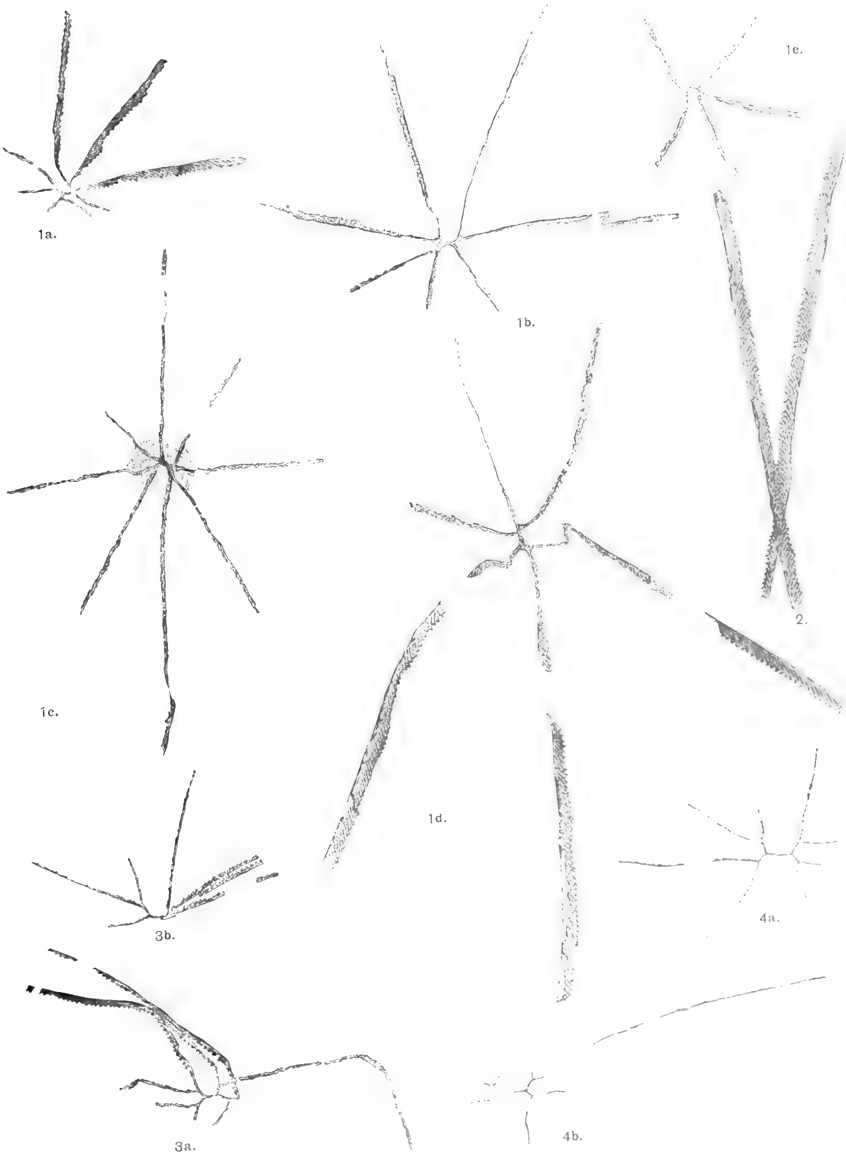
3 *a.* Type specimen of *D. Sedgwickii.* Diagrammatically figured by Salter, Quart. Journ. Geol. Soc., 1863, vol. xix, p. 137, fig. 11. Braithwaite. Skiddaw Slates. Museum of Practical Geology, Jermyn Street.

3 *b.* Seven-stiped example. Carlside Edge. Skiddaw Slates. Postlethwaite's Collection.

4 *a, b.*—*Dichograptus separatus*, Elles.

4 *a.* Type specimen. Quart. Journ. Geol. Soc., 1898, vol. liv, p. 485, fig. 10. Outerside. Skiddaw Slates. Woodwardian Museum.

4 *b.* Ibid., fig. 10.



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DICHOGRAPTUS.

PLATE XI.

Loganograptus, Hall, and **Clonograptus**, Hall.

FIGS.

1 *a—g.*—*Loganograptus Logani*, Hall.

1 *a.* Large specimen. Figured by Nicholson, Monograph of British Graptolites, 1872, p. 109, fig. 52 *c.* ? Skiddaw Slates. British Museum (Natural History), S. Kensington.

1 *b.* Fifteen-stiped form, distorted by cleavage. Barf. Skiddaw Slates. Woodwardian Museum.

1 *c.* Ten-stiped form. Randal Crag. Skiddaw Slates. Woodwardian Museum.

1 *d.* Twelve-stiped form. Gate Gill, Blencathra. Skiddaw Slates. Fitz-Park Museum, Keswick.

1 *e.* Nine-stiped form. Randal Crag. Skiddaw Slates. Woodwardian Museum.

1 *f.* Seven-stiped form. Randal Crag. Skiddaw Slates. Woodwardian Museum.

1 *g.* Eight-stiped form, broader than usual, poorly preserved. Ibid.

2 *a—c.*—*Clonograptus tenellus* (Linnarsson).

2 *a.* Specimen preserved in low relief. Mary Dingle. Shineton Shales. H. M. Geological Survey Collection.

2 *b.* Ibid.

2 *c.* Fragment of distal stipes. Skiddaw Slates. Fitz-Park Museum, Keswick.

3 *a—c.*—*Clonograptus*, var. *Callavei*, Lapworth.

3 *a.* Specimen showing form of thecæ. Mary Dingle. Shineton Shales. H. M. Geological Survey Collection.

3 *b.* Specimen showing stipes of the sixth order. Ibid.

3 *c.* Fragmentary example. Mary Dingle. Shineton Shales. Callaway's Collection.

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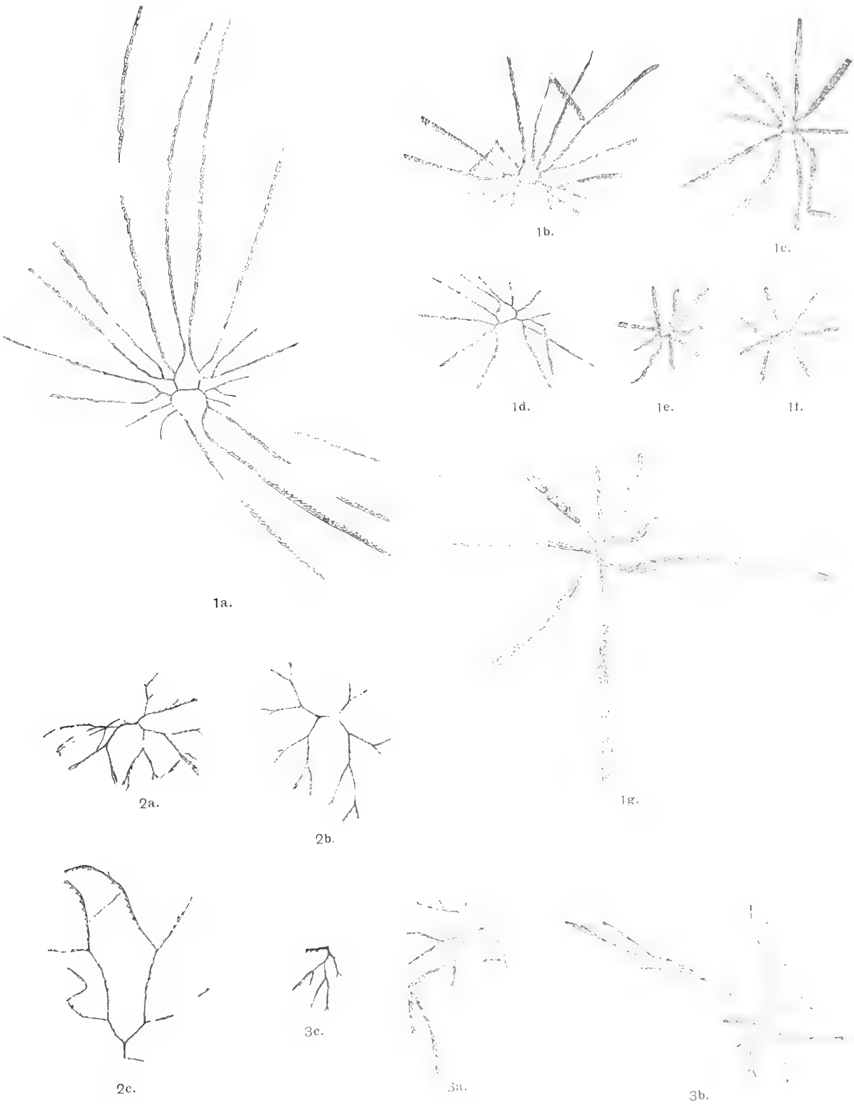
BRITISH GRAPTOLITES. PART I. *PLATE XI.*



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LOGANOGRAPTUS AND CLONOGRAPTUS.

PLATE XII.

Temnograptus, Nicholson ; **Bryograptus**, Lapworth ; and **Trichograptus**, Nicholson.

FIGS.

1.—*Temnograptus multiplex*, Nicholson.

Two specimens on same slab. Right-hand one figured by Nicholson, Quart. Journ. Geol. Soc., 1868, vol. xxiv, pl. vi, figs. 1—3 ; left-hand specimen figured by Elles, Quart. Journ. Geol. Soc., vol. liv, p. 477, fig. 6. Peelwyke, Bassenthwaite. Skiddaw Slates. Christopherson's Collection.

2.—*Bryograptus divergens*, Elles and Wood.

Specimen preserved partially in relief. Figured by Marr as *Bryograptus Callavei* (?), Geol. Mag., 1894, p. 130, fig. 6. Barf. Lower Skiddaw Slates. Woodwardian Museum.

3 *a*, *b*.—*Bryograptus Kjerulfi*, Lapworth.

3 *a*. Specimen figured by Salter as *Dichograpsus*, sp., Quart. Journ. Geol. Soc., 1863, vol. xix, p. 137, fig. 12. Keswick. Skiddaw Slates. Museum of Practical Geology, Jermyn Street.

3 *b*. Large slab, showing specimens of *B. Kjerulfi* associated with its variety v. *cumbrensis*. Figured, Marr, Geol. Mag., 1894, p. 130, fig. 1. Barf. Skiddaw Slates. Postlethwaite's Collection.

4 *a*—*c*.—*Bryograptus*, var. *cumbrensis*, Elles.

4 *a*. Three specimens in association, the largest showing conspicuous sicula with its nema. Figured, Marr, Geol. Mag., 1894, p. 130, fig. 3. Barf. Lower Skiddaw Slates. Woodwardian Museum.

4 *b*. Small specimen on same slab as 4 *a*. Figured, Marr, *op. cit.*, figs. 4, 5.

4 *c*. Specimen from Barf. Lower Skiddaw Slates. Lapworth's Collection.

5.—*Trichograptus fragilis*, Nicholson.

Type specimen. Figured, Nicholson, Ann. and Mag. Nat. Hist. (4), vol. iv, pl. xi, figs. 1—3. Thornship Beck, near Shap. Upper Skiddaw Slates. Natural History Museum, S. Kensington.

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BRITISH GRAPTOLITES. PART I.

PLATE XII

2.

3a.

4b.

4a.

4c.

3b.

5.

1.

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TEMNOGRAPTUS, BRYOGRAPTUS, AND TRICHOGRAPTUS.

PLATE XIII.

Azygograptus, Nicholson, and **Phyllograptus,** Hall.

FIGS.

1 *a, b.*—*Azygograptus Lapworthi*, Nicholson.

1 *a.* Specimens in association showing the sicula. Hodgson-How Quarry, Portinscale. Skiddaw Slates. Woodwardian Museum.

1 *b.* Part of a slab, showing mode of occurrence. Ibid.

2 *a*—*e.*—*Azygograptus Hicksii* (Hopkinson).

2 *a.* Type specimen showing sicula. Figured by Hopkinson as *Tetragraptus Hicksii*, Quart. Journ. Geol. Soc., 1875, vol. xxxi, pl. xxxiii, fig. 12 *c*. Whitesand Bay. Middle Arenig (Hicks). Woodwardian Museum.

2 *b.* Two branches crossed in *Tetragraptus* form. Ibid., fig. 12 *a*.

2 *c.* Accidental association of three stipes. Ibid., fig. 12 *b*.

2 *d.* Specimen showing proximal end, well preserved. Whitesand Bay. Middle Arenig (Hicks). Woodwardian Museum.

2 *e.* Similar specimen. Ibid.

3 *a, b.*—*Azygograptus suecicus*, Moberg.

3 *a.* Portion of one slab, showing the mode of occurrence of this species. Barf. Middle Skiddaw Slates. Woodwardian Museum.

3 *b.* Part of another slab; specimens preserved as casts. Barf. Middle Skiddaw Slates. Postlethwaite's Collection.

4 *a, b.*—*Azygograptus cœlebs*, Lapworth.

4 *a.* Specimen indifferently preserved, but showing sicula. Ellergill. Upper Skiddaw Slates. Woodwardian Museum.

4 *b.* Isolated stipe, showing form of distal thecæ. Figured, Lapworth, Ann. and Mag. Nat. Hist. (5), vol. v, pl. v, fig. 16 *c*. Ellergill. Upper Skiddaw Slates. Woodwardian Museum.

5 *a, b.*—*Phyllograptus*, cf. *typus*, Hall.

5 *a.* Specimen showing characteristic form. Skiddaw Slates. Woodwardian Museum.

5 *b.* Specimen distorted by cleavage. Thornship Beck. Middle Skiddaw Slates. British Museum (Natural History), S. Kensington.

6 *a*—*f.*—*Phyllograptus Anna*, Hall.

6 *a.* Specimen indifferently preserved. Carlside Edge. Skiddaw Slates. Woodwardian Museum.

6 *b.* Elongated specimen preserved as a cast. Ellergill. Middle Skiddaw Slates. Lapworth's Collection.

6 *c.* Specimen preserved as an impression, showing the virgula (?). Figured, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 494, fig. 16. Randal Crag. Skiddaw Slates. Woodwardian Museum.

6 *d.* Small broad specimen. Randal Crag. Skiddaw Slates. Woodwardian Museum.

6 *e.* Specimen preserved as a cast. Skiddaw Slates. Lapworth's Collection.

6 *f.* Very short but broad specimen, preserved as a cast. Bennane Head, Ballantrae. Arenig. Lapworth's Collection.

7 *a*—*f.*—*Phyllograptus angustifolius*, Hall.

7 *a.* Specimen showing typical form. Ellergill. Middle Skiddaw Slates. British Museum (Natural History), S. Kensington.

7 *b.* Broader example. Bassenthwaite Sand-beds. Middle Skiddaw Slates. Woodwardian Museum.

7 *c.* Form associated with *P. typus* (fig. 5 *a*). Skiddaw Slates. Woodwardian Museum.

7 *d.* Narrow example, narrowest proximally. Barf. Skiddaw Slates. British Museum (Natural History), S. Kensington.

7 *e.* Specimen showing well the form of the thecæ. Bassenthwaite Sand-beds. Skiddaw Slates. Woodwardian Museum.

7 *f.* Specimen fairly well preserved. Barf. Skiddaw Slates. Woodwardian Museum.

8.—*Phyllograptus ilicifolius*, var. *grandis*, Elles.

Type specimen. Figured, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 493, fig. 15. North-east of Sleet How, Keswick. Skiddaw Slates. Woodwardian Museum.

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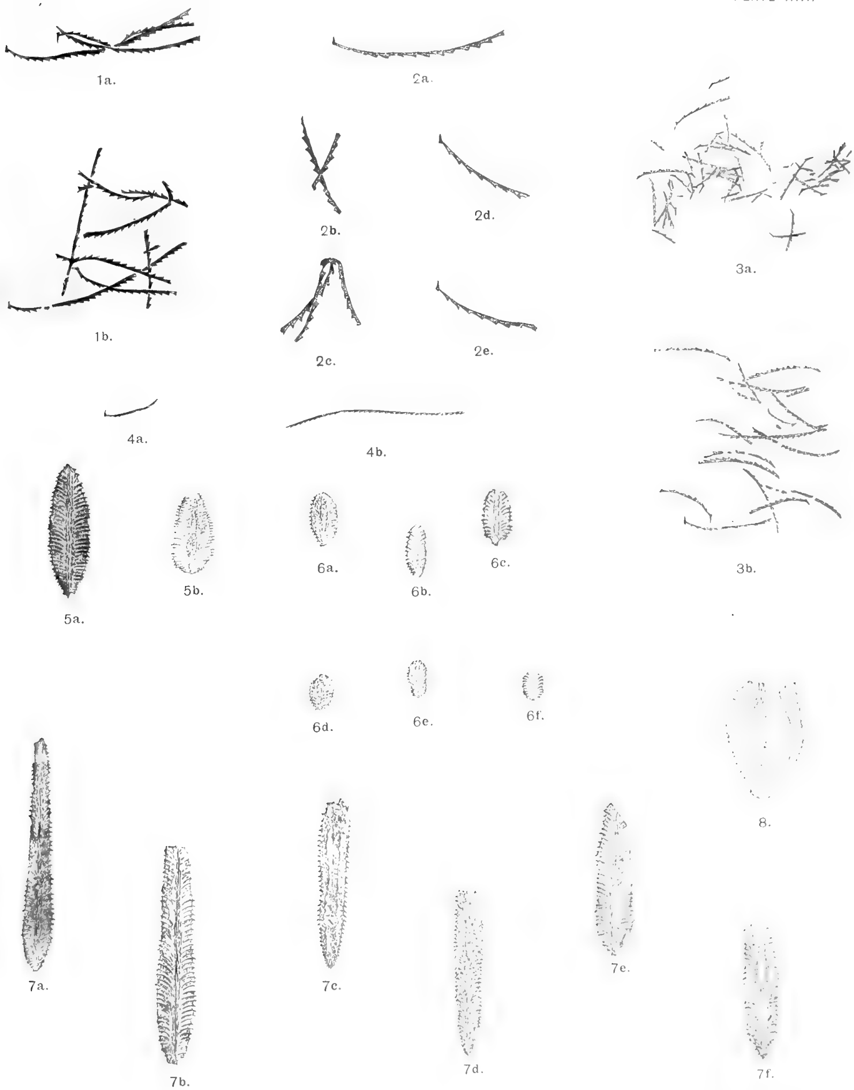
BRITISH GRAPTOLITES. *PART I.* *PLATE XIII.*



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AZYGOGRAPTUS AND PHYLLOGRAPTUS.